POTATO GROWING in the Western States

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RESULTS of long experience, both experimental and commercial, are summarized here to help western potato growers count on high yields and high quality. Advice offered applies to vast areas of western land where potatoes are grown under irrigation and also to scattered districts of the West where rainfall suffices for growing this crop.

Mr. Edmundson tells how the most successful western potato growers manage the soil, select and prepare seed, plant, irrigate, and cultivate; how they harvest and store their product; and how they rotate crops. To statements applying generally through the West, he adds notes on potato growing in individual States.

Dr. Schaal gives up-to-date information to enable the grower to identify potato diseases that are causing serious losses in the West and to guard against losses from disease. He lists a good number of potato varieties that have proved resistant to one or more diseases.

Dr. Landis describes the appearance and gives the life histories of outstanding insect pests, and tells at what stages and by what methods they can be controlled.

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POTATO GROWING IN THE WESTERN STATES

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Contents

POTATOES are grown very extensively in the Western States, chiefly on irrigated land. In recent years dam construction and well drilling have made much additional western land available for growing this crop under irrigation. Potatoes are grown without irrigation on considerable acreages in both humid and semiarid parts of the West. Many of the Western States could increase their present potato-growing acreages.

The average acre yield of potatoes has gradually increased since 1925 in the West as in other parts of the United States. Today the farmer can get potato seed of improved varieties and better quality, he knows better methods for growing the crop, and he can protect the crop more effectively against losses caused by insects and disease.

General information presented in this bulletin applies particularly to the Pacific States, the Rocky Mountain States, and Nebraska.

SUITABLE SOILS AND ROTATIONS

A good potato soil is not hard to find. Its one essential quality is that of remaining porous throughout the growing season. The crop succeeds best on sandy, gravelly, peat, or muck soil. Potatoes should not be planted on soils that would stick to the tubers and crack badly. Heavy soils are harder to prepare than others, tend to puddle when irrigated, and are likely to produce misshapen tubers. Poorly drained soils should be avoided; a topsoil that contains a very large quantity of water much of the time cannot contain enough air to keep potato roots healthy. Even a light sandy topsoil may not drain satisfactorily if it is underlain by a subsoil into which water cannot seep. Good crops of potatoes can be produced on black or clay loam that is well drained.

Potatoes are grown in crop rotations, the purpose of which is to keep the soil fertile, check weeds, and reduce crop losses from insect damage and plant diseases, thus making possible the largest yields per acre of the most profitable crops. Often a western farmer keeps land in alfalfa for 2 to 7 years before planting potatoes on it, grows one crop of potatoes and one of grain, and then puts in alfalfa again. Where sugar beets are grown, usually a crop of beets follows one of potatoes and grain follows the beets. Long rotations are particularly good for reducing potato losses caused by disease organisms that live in the soil. At the Colorado Potato Experiment Station, operated by the United States Department of Agriculture at Greeley, Colo., satisfactory results have been obtained with a 4-year rotation consisting of potatoes on alfalfa sod, a lightly seeded crop of barley or oats, and 2 years of alfalfa. In Idaho some growers plow under what would have been the year's third cutting of alfalfa the fall before they plant potatoes, and some—where wireworms are not a problem—use red clover in the rotation instead of alfalfa. When a short rotation is desired, very satisfactory results may be obtained by substituting sweetclover for alfalfa.

Dry-land farmers commonly plant potatoes on summer-fallowed land or after some cultivated crop such as beans or corn. A small-grain crop is considered unsuitable to precede potatoes on dry land because it practically exhausts available soil moisture to a depth of 4 to 6½ feet or even more. The best conditions for potatoes as to soil moisture storage are obtained by summer-fallowing the land the year before potatoes are grown. In some places where summer-fallowed land is likely to blow badly, growers may find it desirable to sow grain in the fall on land where they expect to plant potatoes in the spring.

IMPROVING AND PREPARING THE SOIL

Commercial fertilizers are now rather generally used in potato production in the Western States, except under dry-land conditions. Some of the western soils need addition of phosphate only, some of nitrogen only, some of a complete fertilizer. The usual method of supplying nitrogen is to plow under alfalfa, sweetclover, or some other leguminous crop. Many potato growers in the West apply large quantities of barnyard manure before planting potatoes. Adding organic matter in either of these ways is very beneficial to most soils.

Most commercial fertilizers are applied at the time of planting in a band about 2 inches to each side of the row of seed pieces and slightly below it. In some districts side dressings of nitrogen are applied after the plants come up.

In preparing sodded soil for potato planting, the farmer works to kill the sod, thoroughly mix it with the soil, and pulverize the soil. Unless he does these things well he cannot expect very high yields.

Whether the soil should be plowed in the fall or in the spring depends largely on whether it is heavy or light and on what crop precedes potatoes. In general, heavy soil benefits from fall plowing, because the action of frost, snow, and winter rain on exposed soil makes it more mellow. Fields from which soil is likely to be washed away by winter rains if plowing is done in the fall, however, should be plowed in the spring. In some parts of the West alfalfa is turned under just before potato-planting time, and neither the cut-off crowns nor the surviving alfalfa plants give trouble.

If land is plowed when too wet, it usually remains in poor condition throughout the growing season.

Thorough plowing of alfalfa sod is very important. The plow should be equipped with alfalfa shears, so that no plants will be left uncut. When alfalfa sod is plowed in the fall, the practice is to plow the soil to a depth of 3 or 4 inches, or just deep enough to cut below the crowns of the alfalfa plants. A deeper plowing follows in the spring. Many growers now use a land chisel to loosen the soil to a depth of 16 to 20 inches, with beneficial results.

Plowing should be followed by harrowing. The harrow will drag out most of the short crowns of alfalfa that have been cut off. On heavy soil, in order to prevent formation of clods and pulverize the soil uniformly, it is good practice to harrow within 2 or 3 hours after plowing. If such soil is plowed in the morning it should be harrowed before noon, and if it is plowed in the afternoon it should be harrowed before night.

Basin listing is sometimes a good way to prepare an area for dry-land potato growing. The basin lister makes a furrow that contains small earthen dams at regular intervals. The dams keep rainwater from running off the surface and thus increase the quantity of moisture that percolates into the soil.

In fields that are to be irrigated, proper leveling of the land (fig. 1) is a very important part of preparing the seedbed.

The value of thorough seedbed preparation under all conditions cannot be overemphasized. Poor preparation cannot be remedied by later cultivations.

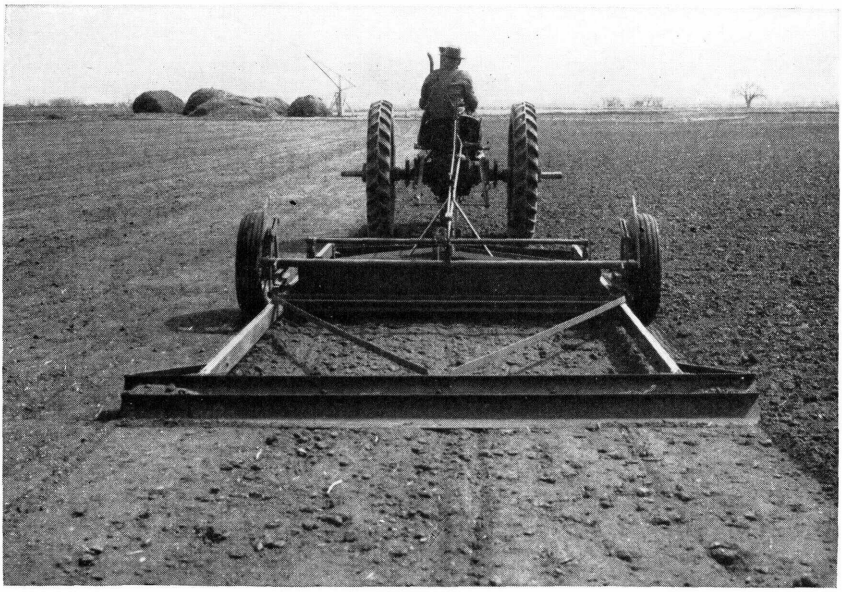

Figure 1.—In preparing a seedbed for potatoes that are to be grown under irrigation, careful leveling is very important.

SUITABLE SEED STOCK

Although much has been said and published on the importance of good potato seed stock, many growers continue to use inferior seed. Seed is satisfactory only if it is of a good variety, true to name, sound, not oversize, and free from frost injury and disease. Planters can now get potato seed of dependable quality from seed-certification agencies or buy it direct from seed growers.

Potatoes of average size are more desirable for seed than large ones, because seed pieces cut from them have smaller cut surfaces. Seed-piece rot, the most common cause of poor stands of potatoes, is generally more severe when the seed pieces have large areas of cut surface.

Potatoes from fields where ring rot is known to have occurred should not be used for seed.

Every potato grower who plans to produce his own seed should establish a seed plot at a distance from other potato fields and plant it by the "tuber unit" method. Well-shaped tubers weighing from 6 to 9 ounces are suitable for this purpose. Each tuber is cut into quarters, and the four pieces are planted one directly after another. Enough space is left between each two of the four-piece units to enable the grower to tell easily which plants come from the same unit. When the grower finds one diseased plant in a seed plot planted by this method, he can easily rogue out along with it all the other plants from the same tuber, before they manifest the disease and become sources of infection.

Certified potato seed stock is produced for the purpose of providing buyers with reliable seed stock as free as possible from infection with seed-borne diseases. It is grown on both irrigated and nonirrigated

lands in all potato-seed-producing States. For many years potato growers were prejudiced against seed stock grown under irrigation, but experiments have shown that irrigation has little or no effect on the vitality of seed and the vigor of plants grown from the seed.

DISINFECTING SEED STOCK

Treating potato seed stock with disinfectants is advisable as a safeguard against losses from disease. Its value is still doubtful in some parts of the West, largely because little or no benefit appears to result from it where soils are heavily infested with the organism causing scab or the fungus causing rhizoctonia canker. As a rule, however, it is wise to treat seed affected with scab or rhizoctonia canker before planting it in such soils, because this may prevent infection of the soil with additional scab organisms or new races of the fungus causing the canker. Viruses and fungi inside the tuber are not killed by seed treatment. The effectiveness of such treatment depends largely upon how closely the operator follows correct instructions. Serious sprout injury may result from incorrect procedure.

The materials used as seed-potato disinfectants are mercuric chloride (corrosive sublimate), acid-mercury (mercuric chloride and hydrochloric acid), formaldehyde, and organic mercury compounds.

MERCURIC CHLORIDE

Mercuric chloride (corrosive sublimate) solution is prepared by dissolving 4 ounces of the chemical in 30 gallons of water and is generally used at ordinary temperatures. It should never be put into metal containers unless they are coated with asphaltum or other protective material.

Soak whole tubers 30 minutes to 2 hours in the solution, using sacks (fig. 2) or, preferably, wooden crates as containers; then allow the

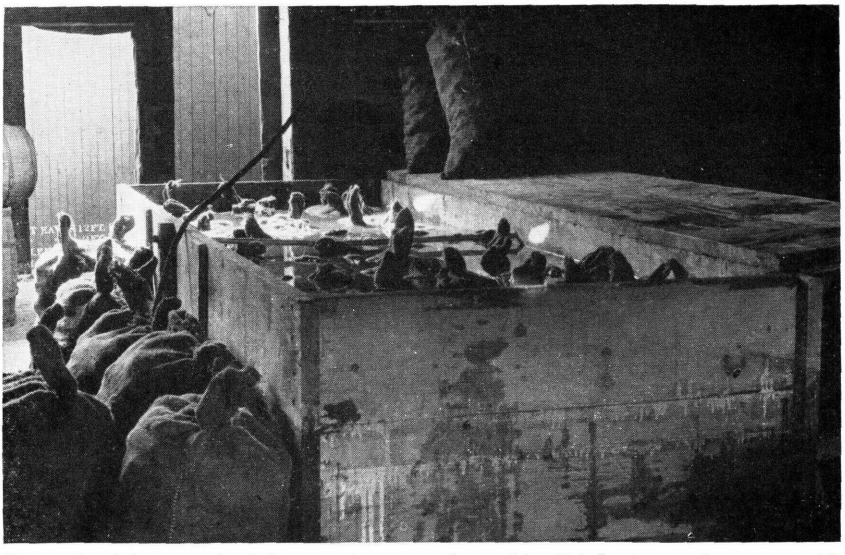

Figure 2.—A large tank of this type is commonly used in disinfecting seed potatoes with mercuric chloride (corrosive sublimate).

tubers to dry. To correct loss in strength of the solution, add one-half ounce of the chemical for every 4 bushels soaked 2 hours, or three-eighths ounce for every 4 bushels soaked 1½ hours. Add water to bring the solution to its original volume. No lot of solution should be used for treating more than four 4-bushel lots of potatoes.

As mercuric chloride is a deadly poison, everyone mixing or handling the solution must take care to keep it away from his mouth, eyes, and nose. He should wear oiled leather gloves and a rubber or oilcloth apron. All vessels used must be thoroughly cleaned before being used again. All clothing and protective devices used must be cleaned afterward. Treated potatoes should never be eaten by humans or animals, and livestock should not be allowed to drink any of the solution. Unused solution should be disposed of in some way that will prevent poisoning of humans or animals.

ACID-MERCURY DIP

To make the acid-mercury treating solution, dissolve 6 ounces of mercuric chloride in 1 quart of commercial hydrochloric acid and add the solution to 25 gallons of water in a wooden barrel or other wooden container. Submerge whole tubers. Remove tubers after 5 minutes, and dry them immediately to prevent injury to their eyes or skins. One batch of solution will treat 25 to 30 bushels of seed. This treatment should be given before sprouts become visible on the seed potatoes; otherwise, it may cause sprout injury.

The acid-mercury dip is gaining in favor over mercuric chloride, because of the short time required for treatment.

Concentrated hydrochloric acid is very caustic and should be handled with great care. Acid-mercury solution is a deadly poison and should be handled as carefully as mercuric chloride.

COLD FORMALDEHYDE

A formaldehyde solution to be used at room temperature is made by adding 1 pint of formalin (40-percent formaldehyde) to 30 gallons of water. Soak whole tubers 1½ to 2 hours.

Cold formaldehyde is irritating to the skin. Oiled leather gloves fitting tightly at the wrists should be worn to keep it from harming the hands. If large quantities of seed are to be treated, a rubber or oilcloth apron should be worn. The solution should be prepared and used outdoors or in a well-ventilated place. If this is not possible, a suitable gas mask should be worn by everyone in the room. Surplus solution should be buried or safely disposed of otherwise. Vessels and clothing used should be thoroughly cleansed afterward.

HOT FORMALDEHYDE

A hot formaldehyde solution is made by adding 2 pints of formalin (40-percent formaldehyde) to 30 gallons of hot water. Whole tubers are immersed in the hot (124° to 126° F.) solution for 4 minutes. Usually the seed is treated in sacks and is allowed to dry in them.

The treatment is more effective if the tubers are dipped into water, drained, and allowed to stand in the moist sacks, or under them, for 24 hours before being treated. After the treatment, the tubers should be covered for an hour; then the filled sacks should be set separately to dry. This aftertreatment is especially important if the potatoes have started to sprout.

The hot-formaldehyde treatment has become popular in some districts, and is being applied to large quantities of seed at community-operated plants, as well as to smaller quantities on farms. Application of this treatment to sprouted seed is questionable.

Heated formaldehyde gives off vapors that irritate the eyes and the respiratory tract. Everyone working with the hot solution should wear a gas mask, whether indoors or out. Other precautions should be taken as just indicated for the cold-formaldehyde treatment.

ORGANIC MERCURY COMPOUNDS

Organic mercury compounds are used as dips according to the methods recommended by the manufacturers. These materials are not corrosive and may be used in metal containers. Seed should be placed in picking baskets and dipped into the solution for a moment only. The baskets of seed should then be placed on a drainboard so that excess solution may drain back into the container.

The same precautions should be taken with organic mercury compounds as with mercuric chloride.

CUTTING THE SEED AND CARING FOR CUT SEED

A large seed piece, such as a quarter of an average-size potato (fig. 3), is much more likely than a small one to produce a sturdy sprout under unfavorable soil conditions.

Many machines for cutting seed potatoes are on the market, some operated by hand and some by power. Although power cutting devices do the job faster, they are likely to produce some pieces without eyes—especially when the potatoes cut are of a variety having few eyes near the stem end.

In some districts seed potatoes are commonly cut with a machine having one or more power-driven disk knives (fig. 4). The knives project through openings in a sloping table surface. Beneath this surface, disinfecting liquids are so placed that the knives revolve through them. The rate of operation is about 16 to 20 revolutions a minute. Tubers piled in a hopper at the rear of the machine roll down to the hands of the operator, who pushes them against the revolving knives. As the potatoes are cut the pieces fall into baskets or onto a conveyor that carries them to an end of the machine, where they drop into sacks or baskets.

The purpose of disinfecting the knives is to keep them from spreading seed-borne disease organisms, such as those of ring rot, from infected to noninfected potatoes. Some growers use boiling water. Others use mercuric chloride (corrosive sublimate) dissolved in water at the rate of 1 ounce to 4 gallons, changing the solution after cutting seven or eight sacks of potatoes.

(See warning regarding mercuric chloride, p. 6.)

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Even if not spread by cutting knives, disease organisms can spread among potatoes waiting to be cut and among cut pieces waiting to be planted. Some growers use a disinfecting solution on the cut seed, but such treatment has not proved entirely satisfactory.

Potato growers in some irrigated areas do not cut seed potatoes but plant whole tubers, because these are less likely to rot or dry in the soil before the sprouts become rooted. In following this practice, only small whole tubers from healthy plants should be used. The common source of whole small tubers for use as seed is commercial fields.

If cut potato seed is exposed to the sun or wind on a hot day for any length of time, it may start to decay before or soon after being planted. On such a day it is good practice to shade all seed taken to the field for planting, including seed left in the planter during the noon hour. A canvas shade, if used, should not be placed so close to the potatoes that hot air will be trapped under it.

Freshly cut seed put in sacks and piled may develop heat, which is one of the principal causes of seed-piece decay.

Cut seed should not be put into unwashed fertilizer bags.

Some growers who plant freshly cut seed pieces dust them with lime to keep them from sticking together.

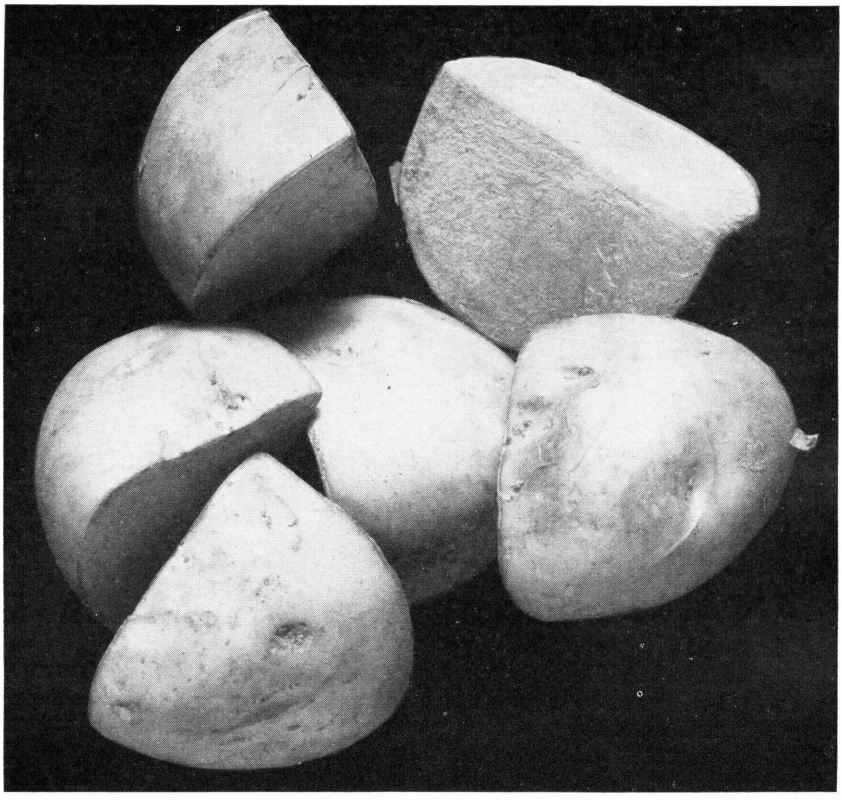

Figure 3.—Large, blocky seed pieces are more likely than smaller ones to produce sturdy plants and even stands.

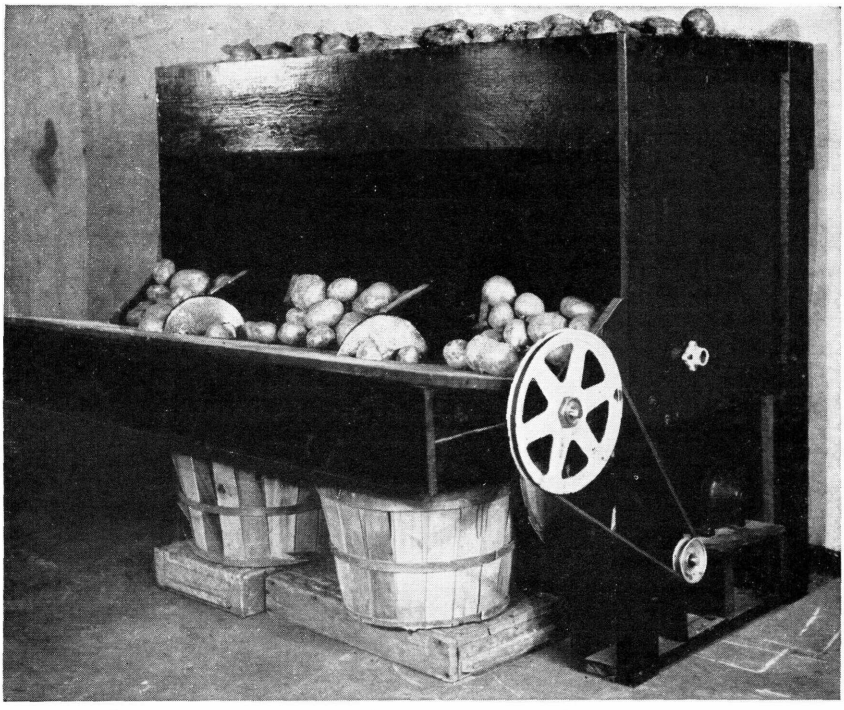

Figure 4.—Potato-cutting machines with power-driven revolving disk knives are common in some districts. Each time the knives revolve they pass through a disinfecting liquid.

Most growers avoid cutting large quantities of seed ahead of the planter, because rain may interfere with planting and unplanted cut seed are likely to deteriorate unless given special care. However, it is safe to cut seed some time in advance of planting if the seed pieces are to be treated in a way that will bring about satisfactory healing of the cut surfaces. Pieces on which such healing has taken place are said to have been suberized.

Seed pieces can be suberized by storing them for 8 to 10 days in a cellar or room that is kept at a temperature of 60° to 70° F. and a relative humidity of at least 70 percent. At the end of that time the seed should be planted or else stored in a cool place. Suberizing of potato seed should not be begun unless it can be completed; partial suberization gives no benefit.

It is a good plan to suberize potato pieces as a protection against decay if they are to be planted in dry soils having high temperatures.

Cut seed pieces that are to be suberized may be placed in baskets, crates, or sacks. Burlap sacks should not be more than half filled, and should be spread out flat, so that the layer of seed pieces in each sack is only 4 or 5 inches deep. An hour or two after the cutting and once again the same day, seed pieces in baskets or crates should be poured from one container to another and sacks of seed should be turned over, so that pieces sticking together will be broken apart.

These precautions to prevent sticking are necessary for all cut seed that is not taken directly to the field for planting.

PLANTING

In planting potatoes, the grower spaces his rows and his seed pieces chiefly according to the fertility of the soil and the quantity of soil moisture available. In dry-land potato production, usually the distance between rows is 42 inches and the seed pieces are spaced 14 to 30 inches apart in the row. Under irrigation, the rows and pieces can be placed much closer together; usually, for convenience in cultivating, ditching, irrigating, and digging, the rows are spaced 34 to 36 inches apart and the seed pieces are planted 9 to 14 inches apart in the row, according to variety and the fertility of the soil. For early potatoes, the distance between rows is sometimes reduced to 32 or even 30 inches. Close spacing is necessary for some varieties under irrigation to keep the tubers from growing too large, to hold growth cracks and hollow heart to the minimum, and to bring about maximum yields. Where rainfall is sufficient to produce a good crop, as in the western parts of Oregon and Washington, the seed pieces are spaced the same as on irrigated land.

Wide ridges are desirable in growing potatoes on most irrigated areas, because they give the tubers ample room for development and also protect them from frost in the fall.

Seed pieces are usually planted 3 to 5 inches deep, or deep enough to make sure that they will be covered at all times with moist soil. Deep planting is more necessary in dry-land farming than under irrigation, and is more necessary for a late crop than for an early one.

Potato planters of three types are now in use—the picker, the cup, and the assisted-feed. The picker planter is the one most generally used, because it can be operated at low expense. Good results may be obtained with machines of this type if the seed potatoes are cut into blocky pieces of about the same size. However, by jabbing into the seed pieces the picker may spread disease-producing organisms from one piece to another. Picker planters should be checked frequently to make certain that they are working right. The cup planter, operated by either two men or one, is best adapted for planting whole seed. The assisted-feed planter is slower and requires two men to operate it. With a competent man assisting the feed, it can be expected to give a perfect drop.

Tractor-drawn units that plant two, three, or four rows at once are now being used by some of the large operators. Because these units plant large acreages in a single day, they enable the grower to take full advantage of his opportunity when soil moisture and weather are right for planting.

Automatic tuber-unit planters are now being used by some seed growers. When whole tubers of the right size are placed in the hopper, the machine cuts them and plants the pieces of each tuber as a unit in correct spacing. The knife is sterilized after cutting each tuber.

The quantity of potatoes required to plant an acre varies, of course, with the size of the seed, the distance between rows, and the spacing of seed pieces within the row. The average quantity required is shown in table 1 according to spacing and to weight of seed pieces.

After potatoes are planted in dry or loose soil, it is good practice to firm the soil with a subsurface packer, especially in semiarid areas where irrigation is not practiced or irrigation water is temporarily

unavailable. This is more important for May or June plantings than for those made earlier.

TABLE 1.—*Average quantity of potatoes required to plant an acre, by spacing between and within rows and average weight of seed pieces* [1]

Space between rows (inches)	Space between seed pieces	Quantity of potatoes required to plant an acre if weight of pieces averages—				
		1 ounce	1¼ ounces	1½ ounces	1¾ ounces	2 ounces
	Inches	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*
30	9	24. 2	30. 3	36. 3	42. 3	48. 4
	10	21. 8	27. 3	32. 6	38. 1	43. 6
	12	18. 2	22. 7	27. 2	31. 8	36. 3
	14	15. 6	19. 4	23. 3	27. 2	31. 1
	16	13. 6	17. 0	20. 4	23. 8	27. 2
32	9	22. 7	28. 4	34. 0	39. 7	45. 4
	10	20. 4	25. 5	30. 6	35. 7	40. 8
	12	17. 0	21. 3	25. 6	29. 8	34. 0
	14	14. 6	18. 2	21. 9	25. 5	29. 2
	16	12. 8	16. 0	19. 2	22. 4	25. 6
34	9	21. 4	26. 7	32. 0	37. 3	41. 8
	10	19. 2	24. 0	28. 8	33. 6	38. 4
	12	16. 0	20. 0	24. 0	28. 0	32. 0
	14	13. 7	17. 1	20. 6	24. 0	27. 4
	16	12. 0	15. 0	18. 0	21. 0	24. 0
36	9	20. 2	25. 2	30. 3	35. 3	40. 3
	10	18. 1	22. 7	27. 2	31. 7	36. 3
	12	15. 1	18. 9	22. 7	26. 5	30. 2
	14	13. 0	16. 2	19. 4	22. 7	25. 9
	16	11. 3	14. 2	17. 0	19. 8	22. 7
42	18	8. 6	10. 8	13. 0	15. 1	17. 3
	24	6. 5	8. 1	9. 7	11. 3	13. 0
	30	5. 2	6. 5	7. 8	9. 1	10. 4
	36	4. 3	5. 4	6. 5	7. 6	8. 6

[1] The averages given in this table are based on data given by W. Stuart on page 63 of his book entitled "The Potato," edition of 1937.

IRRIGATION

Furrows for irrigating potato fields are usually run between rows or pairs of rows. What kind of furrow should be used depends on the type of soil, the row length, and the slope of the land. Ordinarily, the furrows are made with two-row cultivators on which the shovels have been replaced with special ditchers (fig. 5). On flat land with heavy soil, the irrigation furrows must be deep and narrow, so that the water will be applied to the soil below the tubers and will not wet the ridge tops before it has reached the far ends of the rows. If deep furrows are used, the soil in the potato rows is less likely to pack. On a steep slope or in soil of a type that washes badly, small furrows should be used.

On steep slopes only small streams of water should be applied, to prevent washing. Length of run should be governed by the rate at which the soil absorbs water. As a general rule, it is best to avoid runs of over 600 or 700 feet, because they would cause too much seepage at the upper end of the rows.

The usual method of applying irrigation water is to run a small head in each furrow by making a cut into the bank of the head ditch. One cut may serve either for a single row or for several rows. Many growers, instead of cutting into the bank, take water out of the head ditch through horizontal tubes or siphon it over the bank (fig. 6). An adjustable canvas dam may be used in a head ditch to check the flow and thus raise the water level (fig. 7). Two or three such dams are sometimes used if necessary to obtain even distribution of water in the furrows.

The yield and quality of potatoes grown under irrigation depend largely on how the water is used. Irrigation does not injure the quality of the crop if the water is used correctly. In some parts of the West, 3 or 4 applications of water may be sufficient to grow a crop; in others, 5, 6, or even 10 applications may be necessary. At any one place, the number needed varies from year to year as rainfall and other natural conditions vary. In a 14-year study at Greeley, Colo., consistently larger yields were obtained where the soil moisture enabled the plants to make continuous vigorous growth until the tubers reached full size. Frequent light applications (2 to 4 acre-inches) of water gave better results than infrequent heavy ones (4 to 5 acre-inches).

Owing to differences among soils in water-holding capacity and to variations in temperature, rainfall, and other natural conditions, it is impossible to set definite rules as to the time for beginning to irrigate, the number of irrigations, or the time to stop irrigating. This general rule should be followed: Apply the first water whenever the plants seem to need it in order to make continuous vigorous growth, and thereafter keep the soil moist until the tubers have reached full size. Ideally, all the soil except the tops of the ridges is kept moist all the time (fig. 8).

On the peat lands of the delta area at the confluence of the San Joaquin and Sacramento Rivers, in California, irrigation ditches 60 to 75 feet apart and 24 to 30 inches deep are cut between rows of

Figure 5.—Ditching a potato field for irrigation.

Figure 6.—Taking water out of the head ditch with plastic siphons has become a very popular method of irrigating in some parts of the West. (Courtesy of Nebraska Agricultural Experiment Station.)

potatoes. The head ditch with which these ditches are connected receives its water supply through a head gate or siphon direct from river or canal. The soil is open and porous, and raising the water level in the ditches raises the water table throughout the irrigated area. When a tract of land has received the right amount of water, the supply is cut off and the water level is lowered by pumping the excess water back into the river. Some potato lands in the San Luis Valley of Colorado and in the Egin Bench district of Fremont and Madison Counties, in eastern Idaho, are irrigated by raising and lowering the water table in much the same way.

Sometimes, because snowfall or spring rain has been insufficient or because of drying winds or continued hot weather, it becomes necessary to irrigate before planting potatoes (fig. 9) or to "irrigate up" the crop (fig. 10). ("Irrigating up" means applying water immediately after the planting.) If spring plowing has been delayed, the land may be irrigated before it is plowed. When alfalfa sod has been crowned (that is, the tops of the plants have been cut off by very shallow plowing) in the fall and the land has been plowed early in the spring, it is not practical to irrigate by flooding but the land may be furrowed, or ditched, and irrigated before being planted. Irrigating in the fall or in the early spring before planting, if water is available then, is a good practice, preferable to irrigating immediately after the seed goes into the ground.

"Irrigating up" must be done very carefully, especially in hot weather, or it is likely to cause the seed to decay. It can result in good germination and in little decay of seed pieces if the water is applied by the furrow method and only until the moisture reaches the seed pieces or sprouts, without wetting soil above the seed pieces.

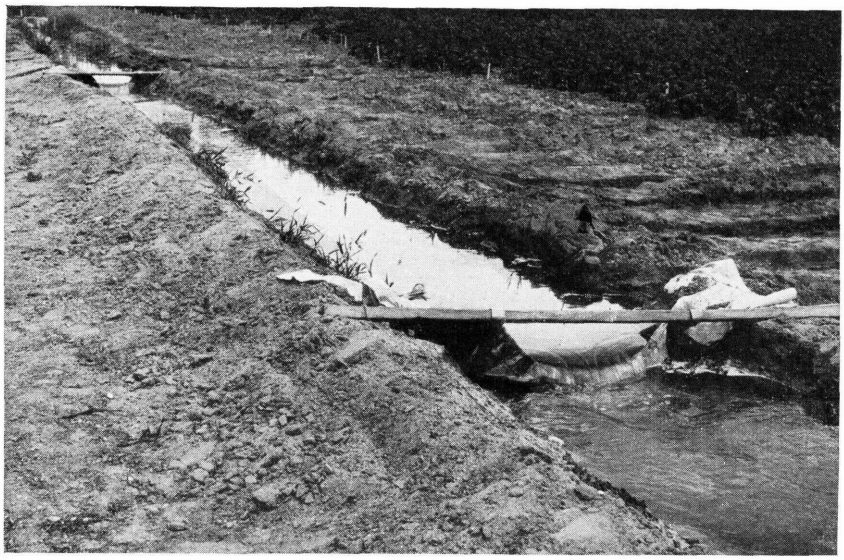

Figure 7.—Adjustable canvas dams, used in head ditches, check the flow of water and raise the water level.

Figure 8.—Plants of the Triumph variety grown from seed pieces planted on the same date: One (left) grown in soil that was always moist; the other (right), in rather dry soil. Note early set of tubers on the plant grown in moist soil.

Where the rows are short, the water is run between all rows. A crop should be "irrigated up" only if the soil lacks moisture sufficient to cause the seed to germinate.

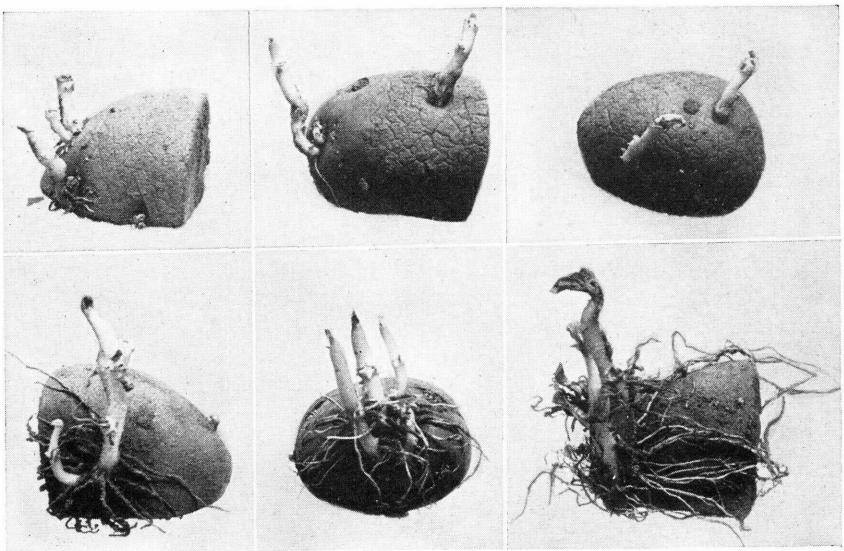

Figure 9.—The seed pieces in the upper row sprouted in dry soil; those in the lower row, which were planted the same day, sprouted in moist soil. Note the difference in root formation.

Figure 10.—"Irrigating up" a field of potatoes, that is, irrigating immediately after the seed pieces are planted.

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CULTIVATION

The chief purpose of cultivating a potato field is to kill weeds and increase absorption of water by the surface soil. Systems of cultivation vary greatly among different potato-growing districts of the West and also within individual districts.

More and more potato growers are using a harrow or a weeder on the potato field before the plants come up. This kills weeds that grow in the rows and breaks any soil crust that forms after rain.

On irrigated lands where the soil tends to pack and run together under irrigation, for best results a cultivation should be given soon after planting. Machine planters leave a ridge over the potato row that can be followed easily. In some districts this cultivation is deep. The shovels are set to work the soil toward the row and thus form a wide ridge at the row and a ditch halfway between rows. In some districts growers do subsurface cultivating soon after planting.

On dry-land areas, except for a ridge 2 or 3 inches high over the row to protect the tubers from sunburn and frost injury, level cultivation is practiced in order to conserve moisture. The soil is cultivated only enough to kill the weeds and maintain a surface mulch. One or two cultivations generally suffice, and some fields are never cultivated.

HAIL INJURY

Hailstorms within the growing season may cause serious damage to potato plants (fig. 11). A fall of hail, which is generally accompanied by wind and heavy rain, often defoliates the plants and breaks their stems. Potato plants badly injured by hail may still produce a good yield if sufficient growing time remains and conditions are favorable for vine growth and tuber development. Stem wounds caused by hail heal quickly, and stems that have been beaten to the ground gradually become erect and develop new branches and leaves. Healthy, vigorous plants with well-developed root systems have a much better chance of recovery than weak or diseased ones. Plants that are destroyed to ground level have little chance to recover; generally, their underground stems rot, whereupon further growth becomes impossible.

When plants have been injured but not destroyed by hail, it is advisable to work the soil into good physical condition immediately if this can be done without further injuring the plants. Other cultivation should be delayed until the plants become more erect. After that, regular cultural practices should be followed.

Plants that are badly injured by hail after tubers have formed must develop new tops before the tubers can make any further growth. If their tubers are partly developed at the time of injury, these tubers may mature without growing any larger, may develop the knobby form known as second growth (discussed later), or may send out sprouts or stolons. Generally, the best tubers produced by hail-injured plants are small ones that would have remained undeveloped under normal conditions. An early crop has a better chance of producing well after hail injury than a late one; the late one may not have sufficient time before frost to develop fully. If injury to vines occurs near the normal harvest period, usually the crop should be harvested early.

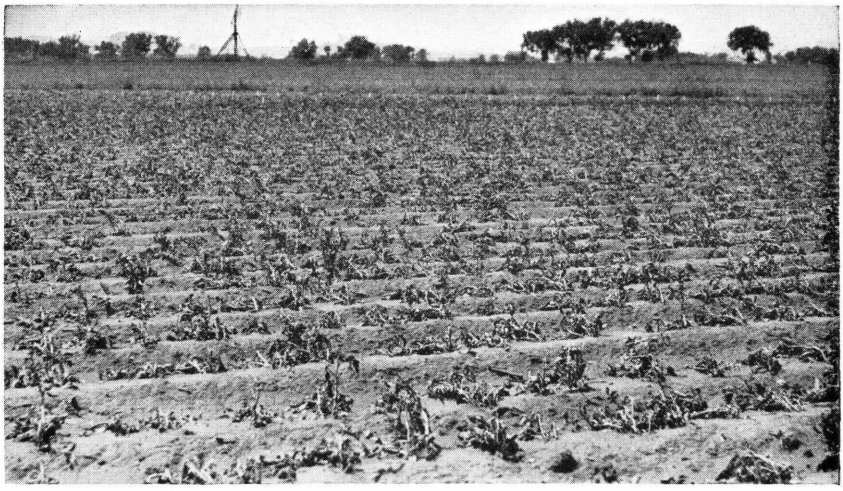

Figure 11.—Potato crop on an area in Colorado that was planted June 2 and severely injured by hail July 13. In spite of this injury the plants produced over 400 bushels an acre.

HARVESTING

It is now common practice to kill potato vines before harvest, in order to hasten tuber maturity and make harvesting easier. The usual instruments are mechanical beaters and oil-burning flame throwers. A mechanical beater (fig. 12) has numerous low-hanging flails that revolve at right angles to the ground surface and thus shred the vines. The shredded stems and leaves are thrown forward and upward against the cover of the machine, from which they fall to the

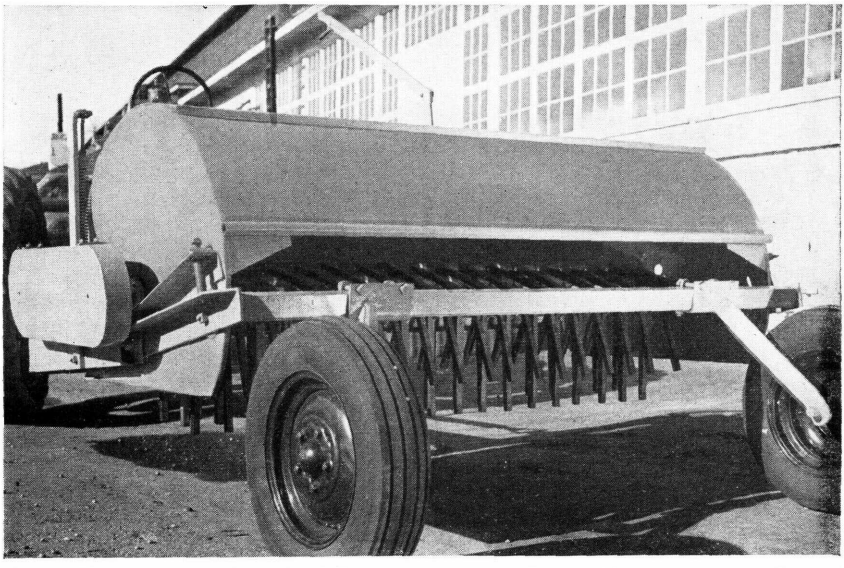

Figure 12.—Beater machine for killing potato vines, thus making it easier to dig and pick the crop. Revolving flails reduce the vines to shreds.

ground (fig. 13). Some of the growers who use flame throwers do the work in two operations, the first of which merely scorches the vines to check growth. The foliage should not be completely burned, for this would involve loss of some nitrogen. Spraying with chemical weed killers to hasten maturity has met with some success as a method of killing potato vines. Flame throwers and some chemical weed killers may cause stem-end discoloration of tubers, especially if the soil is dry.

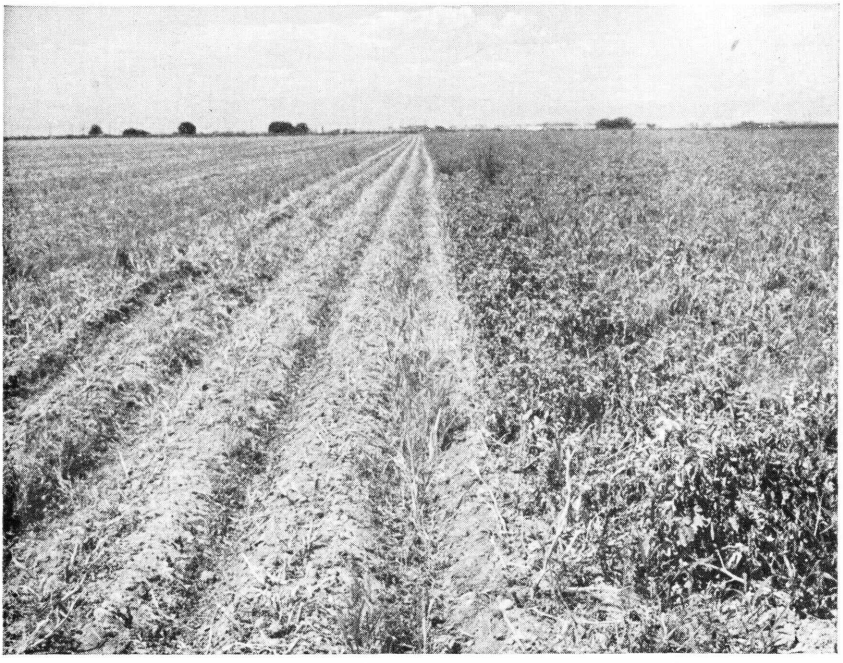

Figure 13.—Potato vines (left) shredded by machine shown in figure 12.

Vines of an early crop, which is usually harvested in hot weather, are generally killed only 2 or 3 days before the potatoes are to be dug. Vines of a late crop may be killed farther in advance of digging. No information is available as to just how much time should elapse between killing and harvesting. Killing the vines too soon not only causes a loss in yield but leaves tubers of a late crop more subject to freezing damage. With the Triumph variety, if the roots are not dead and the tubers are not mature enough for harvesting, removal of the vines may increase cracking.

In some districts growers cut the roots of potato plants to hasten tuber maturity, with a machine having two sharp blades that move horizontally through the ground about 2 inches below the tubers. The plants are undercut 2 or 3 days before the digging. Undercutting gives best results when the soil is not very moist; in very moist soil, it has little immediate effect on the plants. If undercutting loosens the soil too much, it may make digging difficult.

In the early-producing potato districts, high prices and active demand often lead growers to harvest tubers that are immature or only

partly grown. If such tubers are dug during hot weather, they should be picked up immediately to prevent sunscald. It may be safer to harvest them only during the cool part of the day—that is, before 9 or 10 a. m. and after 4 p. m.

Tubers showing any sign of heat damage should be harvested as soon as the vines begin to mature.

Potatoes of the late crop are generally harvested when the vines mature or soon after a killing frost. In most of the western potato-growing districts, harvest of a late crop begins about September 25 and lasts about a month.

Immature tubers scar easily and must be harvested with care if they are to make a good appearance on the market. Mature potatoes, also, should be harvested as carefully as possible; if injured at the time of harvest they are likely to rot in storage.

Potato diggers have been considerably improved in recent years. The wide, low type of digger with a continuous chain does much less injury than earlier types. Machines that dig and sack the potatoes are being used to some extent. Although they need improvement, some of them give good results. They operate best on light soils.

Use of the picking belt, which permits placing potatoes in sacks as soon as they are picked (fig. 14), not only makes harvesting a quicker job but has done much to eliminate bruising of tubers. The sacks are filled about halfway to the top and then left in the rows.

Careful handling of potatoes in loading them in the field is very important.

Figure 14.—A picking belt that holds a sack in convenient position before the potato picker saves harvesting time and eliminates much bruising of tubers. (Courtesy of Colorado Agricultural Experiment Station.)

Throughout the West, potatoes to be marketed are usually placed in newly branded burlap sacks. Cotton sacks of various sizes and small cartons, also, are used. In most of the western potato districts, potatoes that are to be marketed without going into storage are commonly washed to improve their appearance.

STORAGE

Most growers of late-crop potatoes cannot sell all their product at the time of harvest, or cannot do so profitably, and therefore need to provide for storage. Storage on the farm or at a trackside site near the farm is more economical than storage at a marketing center.

In order to hold potatoes in storage for periods of usual length and still keep them in condition to meet market requirements, it is necessary to give them more than shelter from the weather. The storage house or cellar should be so designed and managed that losses from shrinkage and rot during storage will be held to a minimum.[1] Provision should be made, also, for handling the potatoes conveniently in storing them and in grading them.

On irrigated lands of the Mountain States and in the Klamath district of southern Oregon, potato storages are usually built on level sites; in dry-land areas they are often built on knolls or hillsides. Usually a small storage has a single entrance at one end but a large one has doors at both ends so that it can be driven through. Cellars of the old deep, earth-covered type require much ventilation in the fall to cool them; but they afford good storage through late spring and are practical where rainfall is rather light and low-cost poles are available to support their roof load, which ranges approximately from 100 to 200 pounds per square foot. Where poles are expensive, it is usually more satisfactory and economical to build with mill lumber and fill-type insulation (fig. 15).

In recent years a new type of storage has been introduced, in which the bins have tight floors and walls and are separated from the floor and walls of the building by spaces for air circulation. The tight floors and walls of the bins prevent excessive air circulation among potatoes, and thus prevent excessive shrinkage losses that occur among potatoes stored in slat bins in the low-humidity air of the Mountain States. The air spaces around the bins help in keeping the potatoes within a narrow temperature range and thus reduce both freezing injury and sprout loss. This type of storage is gradually replacing that in which the bins have slatted floors and walls.

Potatoes are stored 6 to 8 feet deep in some cellars, and 16 feet deep or deeper in some of the new-type storage houses.

When being put into storage, potatoes should be poured out of the sacks carefully—never thrown. Men working in a storage house or cellar should walk not on the potatoes but on planks, padded underneath, laid over the potatoes.

Potato injuries heal better if the air of the storage house is kept at a temperature of about 60° F. and at high humidity for the first 2 weeks of storage. This can be done by restricting ventilation. After this curing period, the temperature need not be reduced below 50° or

[1] For detailed information on storage of potatoes, see Farmers' Bulletin 1986, Potato Storage.

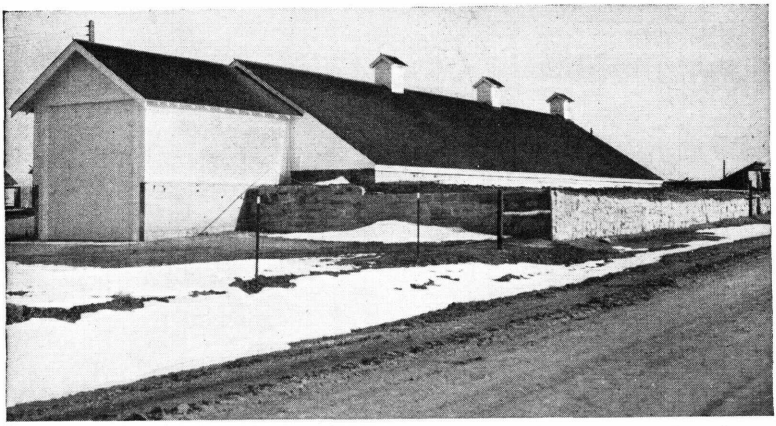

Figure 15.—Potato storage house built according to a modern construction plan on a farm in Colorado. This house has such interior features as fill-type insulation, a vapor-resistant lining, and forced ventilation.

55° if all the potatoes are to be shipped within 120 days. If much of the stored crop is to be kept longer, it is desirable to lower the storage temperature to between 38° and 40° within 90 days after the potatoes are placed in storage. This is to prevent excessive sprout losses, which become serious after 4 to 6 months of storage at temperatures above 40°. If potatoes placed in storage have been infected with late blight or pink rot, the temperature should be lowered as soon as possible. Potato shrinkage is increased by high temperatures, low humidities, and mechanical injury. Under good storage conditions potatoes shrink only 5 to 6 percent in 4 months.

In some potato storages, forced circulation of air is automatically controlled.

It is advisable to disinfect a storage house or cellar every year, especially if tubers infected with ring rot have been stored in it. A solution of 1 to 2 pounds of copper sulfate in 10 gallons of water has given good results. The solution should be sprayed thoroughly on the bin boards and floor. It may be used also on sorters and other equipment. Formaldehyde is effective if the fumes are confined for a period of 24 to 48 hours, but is more disagreeable to use.

POTATO GROWING IN INDIVIDUAL STATES

Principal features of the potato industry in each of the Western States are briefly outlined here. More detailed information may be obtained from State agricultural colleges, agricultural extension services, and county agents.

ARIZONA

Arizona's potato production is rather limited. In Coconino County, once the State's principal dry-land potato district, growing of this crop has been greatly reduced owing to serious outbreaks of ring rot and to increases in prices paid for beans and grains. In the southern part of the State potatoes are grown under irrigation, principally in Maricopa and Pinal Counties and to a small extent in Greenlee County. Here, planting is completed by February 15. Triumph,

White Rose, and Red Warba are grown in Maricopa and Pinal Counties, White Rose alone in Greenlee County.

CALIFORNIA

California has three principal potato-producing districts, all irrigated: The delta area of San Joaquin and Contra Costa Counties, sometimes referred to as the Stockton district; Kern County; and the Klamath district, in Siskiyou and Modoc Counties, along the State's northern boundary.

In the Stockton district, much of the land lies below river level. Water taken from river or canal through a head gate or a siphon is applied to the land in narrow ditches 24 to 30 inches deep and 60 to 75 feet apart. The principal varieties grown are Burbank and White Rose. Prevailingly, the early crop is planted in March or April and the late crop in May or early June.

The Kern County district has elevations ranging from 350 to 550 feet. Its rainfall, which occurs between October 1 and May 1, averages only about 5.5 inches a year. The principal variety grown is White Rose. Planting is done between November and the middle of March.

The Klamath district has elevations of 4,035 to 4,200 feet. Its rainfall averages about 12.5 inches a year and occurs chiefly between September and June. Irrigation water is obtained from Upper Klamath Lake and the Klamath River. Russet Burbank is the leading variety; White Rose, Burbank, and Triumph are grown on small acreages. The crop is planted in April or May and harvested in October.

California growers consider use of fertilizer essential. In Kern and Riverside Counties, ammonium sulfate is applied at rates of 400 to 800 pounds an acre, and some phosphate is added to the soil of fields constantly used for potato production. In the Stockton district old fields receive 500 to 1,000 pounds an acre of a 10–10–10 fertilizer, and new or burned-over peat land receives 0–10–10 fertilizer at about the same rate. In the Klamath district a 16–20–0 or an 11–48–0 fertilizer is applied at the rate of 400 pounds an acre.

COLORADO

Colorado's principal potato-producing districts are the San Luis Valley, which includes five counties in the south-central part; the Greeley, in the northern part; and the Western Slope. A quantity of seed, including some of excellent quality, is produced with and without irrigation in a number of smaller districts—the northeastern, Divide, San Juan, Moffat, and South Park-Pikes Peak.

The San Luis Valley is 120 miles long and 60 miles wide, with altitudes of 7,500 to 8,500 feet. Precipitation averages less than 10 inches a year, and all potatoes are produced under irrigation. Irrigation water is drawn from the Rio Grande, which heads in the mountains on the west side of the valley. Parts of the valley are subirrigated. Field ditches for subirrigation are spaced 60 to 70 feet apart. Water is run in these ditches until moisture is brought near the surface, and the water table is maintained at the desired level by regulating the flow. Row irrigation, also, is practiced. The leading varieties are Red McClure, Triumph, and White Rose.

The Greeley district is the oldest commercial potato-growing center in the State and was the largest until the beginning, in 1909, of an unusually severe and widespread epidemic of a disease believed to have been psyllid yellows, which lasted several years and nearly ruined the district's potato industry. An early crop is grown mostly in the Gilcrest area, south of Greeley, where the soil is sandy and well adapted for the purpose. Irrigation water for the district is supplied by the direct flow of river water and from reservoirs and wells. The leading varieties for the late crop are Triumph, Katahdin, Rural New Yorker No. 2, Irish Cobbler, Russet Rural, and Yampa; those for the early crop are Triumph, Irish Cobbler, and Russet Burbank.

The district known as the Western Slope has altitudes ranging from 4,500 to 9,000 feet. Its soils vary greatly. Ample water for irrigation is available from streams throughout the district. At the highest elevations, irrigation is unnecessary. The principal varieties grown are Rural New Yorker No. 2, Red McClure, Katahdin, Russet Burbank, and Russet Rural for the late crop, Irish Cobbler and Triumph for the early crop.

In Colorado, use of commercial fertilizer in growing potatoes has not become a general practice but is increasing. In the Greeley district most growers of the early crop apply commercial fertilizer at the time of planting and side dress with nitrogen later.

Flea beetles and the potato psyllid are the most common insect pests of the potato in Colorado.

IDAHO

Idaho's commercial potato crop is grown chiefly on irrigated lands lying along the Snake River. The counties leading in production are Bingham, Bonneville, Twin Falls, Cassia, Minidoka, and Fremont. Other counties producing potatoes as an important commercial crop are Jefferson, Madison, Bannock, Canyon, Owyhee, Jerome, Lincoln, and Gooding. Over 95 percent of the potatoes produced are of the Russet Burbank variety. White Rose and Triumph are produced as early potatoes in the southwestern part of the State.

Soils in the principal potato-producing areas of Idaho are well adapted to the purpose. The use of phosphate has been increasing steadily. This fertilizer is usually applied to alfalfa preceding potatoes. A mixed fertilizer is frequently used on the second crop of potatoes following alfalfa. It is common practice to plow under what would have been the year's third cutting of alfalfa in the fall when potatoes are to be planted in the spring. Where wireworms are a problem, the use of clover as a green-manure crop is not advisable.

Production of certified seed has increased steadily since 1940. Of the State's 44 counties, 24 are now producing certified seed. Those leading in this activity are Fremont, Teton, Butte, Valley, Lewis, and Bonner. Most of the certified seed produced in Idaho is used within the State. The commercial growers' practice of buying certified seed and increasing it 1 year for their own use is decreasing; the "1-year-out" seed thus produced has failed to give satisfactory results in most commercial growing areas, owing to rapid spread of virus diseases.

The northern counties of Idaho, having fairly high annual precipitation, produce potatoes without irrigation. The potato acreage

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of Fremont County is about half dry land, half irrigated. In Teton, Butte, and Valley Counties, the potato crop is irrigated.

Correct timing of the first irrigation is very important to production of well-formed russet tubers. Bottleneck- and dumbbell-type tubers frequently result from withholding the first irrigation too long. Malformed tubers of these types may result also from allowing the plants to become dry at any time during the growing season, from hail or frost injury, or from anything else that checks the growth of the plants.

About half the potatoes grown in Idaho are harvested with combines. The type of potato combine most commonly used is the trailer, which digs the potatoes, culls out the vines and clods, dumps the potatoes into field sacks, and sets the sacks on the ground.

Loss in yield, varying in severity from year to year, is suffered annually in Idaho because of "early dying," or verticillium wilt. This disease has become a problem in the irrigated lands along the Snake River from Fremont County to Twin Falls County.

MONTANA

In Montana, potato production is widespread. It is practiced both under irrigation and on dry land. Districts that are important centers of production include the Flathead Lake, Bitterroot, Deer Lodge, Helena, Milk River, Yellowstone, Sun River, Beaverhead, Jefferson, and Gallatin.

Seed production is an important part of the Montana potato program. Most of the seed used in the State is produced there, and many carloads are shipped out of the State annually. Seed production has become a specialty in some districts.

The leading commercial varieties are Russet Burbank in the western part of the State and Triumph in the eastern part. In several valleys White Rose seed is grown in large quantities for out-of-State shipment. Varieties such as Irish Cobbler and Katahdin are grown in limited quantities.

Use of commercial fertilizers has been found beneficial in all parts of Montana. The practice of applying 150 to 200 pounds of a 10–20–0 mixture has become nearly universal and is contributing directly to great improvement in yield and grade. Responses to commercial fertilizers are found to be closely associated with high organic content of the soil. It has become common practice, when potatoes are to follow alfalfa, to plow under what would otherwise be the year's last cutting for hay.

Building up the organic content of the soil by use of sweetclover and other crops has been found to pay dividends.

NEBRASKA

Conditions affecting potato culture in high-altitude areas of northwestern Nebraska closely resemble those in neighboring States to the west. Potatoes are grown in western Nebraska both with and without irrigation. The North Platte Valley, in Scotts Bluff, Sioux, and Morrill Counties, is the principal irrigated district. Other irrigated districts are in Kimball and Cheyenne Counties, where water is supplied from a storage reservoir and by pumps from wells; in Box

Butte County and Lodgepole Valley, where pump irrigation is used; and in the Niobrara Valley, in the southern part of Dawes County, where potato growing has been begun recently with irrigation water supplied from reservoirs.

Planting dates recommended for Triumph and other early scab-susceptible varieties are June 10 to 25. Earlier planting is discouraged because it permits greater build-up of insect infestations and greater scab damage to tubers. As seed stock of scab-resistant varieties becomes available, planting may be done earlier. The crop is harvested from September 25 to the middle of October.

The dry-land seed-producing districts are principally in Box Butte, Sheridan, Dawes, Sioux, Kimball, and Banner Counties. Dry-land seed production in Nebraska was materially decreased by drought in 1934–37, but it is steadily increasing as more potatoes are planted on fallowed land.

The principal variety grown is Triumph. Red Warba is grown to a limited extent on dry land as seed for central Nebraska. Most of the late-maturing varieties have been discarded; however, Katahdin is being grown to some extent in the North Platte Valley, and some of the late white scab-resistant varieties are attracting interest. Distinct strains of Triumph that differ in time of ripening have been isolated in Nebraska. A midseason strain is the one most extensively grown. Although late strains produce higher yields, they tend to produce larger percentages of rough tubers; consequently they are considered less desirable than the early strains.

Flea beetle is the most serious pest. Sprays have been used to control it, but at present dusts appear to be replacing them.

NEVADA

In 1945, according to census reports, Nevada produced potatoes under irrigation on 2,946 acres, a total greater than that of 1940. Lyon and Washoe Counties had the greatest potato acreages. The Lovelock Reclamation Project includes some areas well adapted to potato culture. Russet Burbank is the leading variety. The crop is generally planted between May 15 and June 1.

Areas in Nevada now being used for potato culture are small and are widely scattered. The location of the growing areas makes marketing difficult.

NEW MEXICO

The potato crop of New Mexico has comparatively little commercial importance. It is produced principally in the San Juan, House, Bluewater, Deming, Virden, middle Rio Grande, and Mesilla districts. In the southern part of the State the usual potato-planting season is February 15 to March 1; in the central part, April 1 to 15; in the northern part and at higher altitudes, May 1 to 15. The principal varieties are Pontiac, Irish Cobbler, Triumph, and White Rose.

In the irrigated areas of the State, most growers get good response to commercial fertilizers. Ammonium nitrate or ammonium sulfate is commonly used, alone or in combination with superphosphate. Rates of application range from 200 to 600 pounds per acre. The usual practice is to make two applications as side dressings, the first

when the plants are 4 to 5 inches high and the second about blooming time. Some growers prefer to apply part of the fertilizer at planting time.

In southern New Mexico, psyllids and leafhoppers are the most destructive insects. In the northern areas, in addition to these pests, flea beetles cause some damage. Early blight is a major problem.

OREGON

Oregon has two very distinct climates. The western part of the State has a rainfall of about 40 inches and the part east of the Cascade Range generally has less than 14 inches. Both parts have dry summers.

The largest potato-production districts are the central Oregon, south-central Oregon, Willamette Valley, Malheur, and Blue Mountain. In the central and south-central Oregon districts of Crook, Deschutes, Jefferson, Klamath, and Lake Counties, potatoes are grown on about 25,000 acres of land annually. Nearly half this acreage is in Klamath County. Russet Burbank is the one variety of commercial importance grown in these districts. The acreage is all irrigated, and it is expanding as new lands are brought under irrigation. Two main crop rotations are used. The first is alfalfa for 5 or 6 years and potatoes for 2 or 3 years; the second is grain for 1 year, alsike clover for 2 years, and potatoes for 2 years. The soils are alkaline. Various fertilizers are used, with nitrogen as the chief element.

The potato acreage of the Willamette Valley is mainly in the northern end, which includes Washington, Multnomah, Clackamas, and Marion Counties. White Rose is the leading variety, but market gardeners near Portland produce many other varieties in local demand. Burbank is still one of the favorites. In recent years White Rose seed stock has been grown on 1,000 to 2,000 acres annually for shipment to California. In the Williamette Valley very little land is irrigated, but supplemental irrigation by sprinkling is gradually increasing. Many different crop rotations are used. The soils are acid. Fertilizers carry less nitrogen and more phosphorus and potassium than in the central Oregon district. About half the potatoes are planted in February or March for the early crop and half in late June or July for the late crop.

The Malheur district, in the extreme southeastern part of the State, produces mostly early potatoes that are shipped in July. Triumph, Pontiac, and White Rose are the principal varieties. The acreage is all irrigated.

In the Blue Mountain district, some dry-land seed potatoes are grown and there is a small commercial acreage under irrigation in the valleys. Russet Burbank and White Rose are the leading varieties.

UTAH

Utah produces early, midseason, and late potatoes. The early and midseason crops are grown largely in the northern part of the State in Box Elder, Weber, Davis, Morgan, Cache, and Utah Counties. The principal varieties are Triumph and Irish Cobbler. The late crop is produced chiefly in the extreme northern, south-central, and southwestern parts of the State, comprising Cache, Box Elder, Sevier,

Piute, Garfield, Beaver, and Iron Counties. Russet Burbank is the leading late variety; Triumph and, to a lesser extent, Katahdin are grown as a late crop in the northern part of the State.

Seed potatoes are grown at high elevations in mountain valleys. These are largely of the White Rose and Russet Burbank varieties. Practically all the White Rose seed stock and a large part of the Russet Burbank are shipped to California for use by commercial producers. Triumph seed stock is produced to a limited extent.

Nitrogen and phosphate fertilizers often improve yield and quality appreciably. The ratios most commonly recommended are 16–20–0 and 10–20–0. Rates of application of these concentrated fertilizers range from 200 to 500 pounds per acre. Furrow irrigation is practiced almost exclusively. The soil is kept moist through the greater part of the growing season.

WASHINGTON

Western Washington has a climate very similar to that of western Oregon; the eastern part of the State is semiarid but has somewhat heavier rainfall than eastern Oregon. The counties leading in commercial potato production are Yakima, Kittitas, Spokane, Benton, and Grant. Yakima and Kittitas Counties produce over half the State total. The leading commercial varieties are Russet Burbank and White Rose. White Rose is used mostly for the early crop. Early potatoes are produced in Yakima, Benton, and Grant Counties.

Seed potatoes are grown principally in the western counties Skagit, Snohomish, and Whatcom and in the eastern counties Spokane, Pend Oreille, and Whitman.

On irrigated areas the crop rotation in general use is wheat, oats, or corn for 1 year; alfalfa for 2 to 4 years; and potatoes for 1 or 2 years.

The early crop is planted in March and April in the coastal district, before April 6 in the Yakima and Moses Lake areas, and in April in the most easterly part of the State. The late crop is planted in May and early June in the western and most easterly parts of the State, and in late June in the central irrigated areas.

In western Washington potato growers usually apply 1,000 to 2,000 pounds of 5–10–10 fertilizer per acre on mineral soils and 800 to 1,200 pounds of 3–10–20 per acre on muck soils. In central and eastern Washington, if alfalfa has preceded potatoes they broadcast 150 pounds of ammonium sulfate and 100 pounds of treble superphosphate per acre before plowing; otherwise, they apply 400 pounds of ammonium sulfate and 200 pounds of treble superphosphate per acre.

In the irrigated district a common practice is to make two applications of 16–20 Ammophos, the first in bands when the potatoes are being planted and the second when they begin to bloom.

In the western part of Washington, where the temperature seldom falls much below freezing, potatoes are stored in barns or sheds; in the eastern part they are stored in pits, dugout cellars, and various types of storage rooms.

The virus disease leaf roll is one of the main causes of reduced potato yields in Washington and may cause still greater loss by lowering the grade of the product.

In Wyoming, potato-producing areas range in altitude from 4,000 to 8,000 feet. Potatoes are grown both under irrigation and under dry-land conditions. The dry-land potato districts have an annual rainfall of about 15 inches.

The principal centers of potato production are Goshen, Laramie, Fremont, Park, and Sheridan Counties. Goshen County has the largest irrigated acreage, and Laramie County has the largest dry-land acreage. Potato production is increasing in several districts recently brought under irrigation.

No commercial fertilizers are used on the dry-land fields. In the areas under irrigation, a few growers are applying some nitrogen and phosphorus fertilizers but most of the growers plow under legume crops to supply nitrogen.

Triumph is the principal variety. Others grown are Irish Cobbler, Russet Rural, Red Warba, Red McClure, Russet Burbank, and Teton. A large proportion of the potatoes grown in Wyoming are sold for seed.

DISEASES AND THEIR CONTROL

Potato diseases and methods of controlling them are somewhat different in the West than in the East and the South, partly because climate and soil conditions are different. Several such diseases, including some that at times become epidemic, are peculiar to the West. The most common and serious diseases of potatoes in the Western States are described here, and the best available information is given on methods of controlling them.

Among the most effective means of combating potato diseases is use of varieties that are resistant to one or more diseases. Largely through the potato-breeding program now being carried on cooperatively by the United States Department of Agriculture and the State agricultural experiment stations, a number of such varieties have been developed and introduced. These varieties are named here in the discussions of individual diseases. The grower is warned that before buying a large quantity of high-priced seed stock on the basis of a variety's disease resistance, he should make sure how well the variety is adapted to growing conditions in his district.

DISEASES KNOWN OR SUSPECTED TO BE CAUSED BY VIRUSES

Virus diseases that are sometimes serious on potatoes in the Western States include mild mosaic, rugose mosaic, leaf roll, and spindle tuber. Other potato diseases in the region that may be virus-caused include calico, witches'-broom, haywire, psyllid yellows, and purple-top wilt.

If a plant is affected with a virus disease, plants produced from its tubers will be diseased. Thus, in producing seed potatoes every effort should be made to remove all plants so affected as soon as they show symptoms. Virus diseases of potatoes are spread mainly by aphids and other insects. It is very important, therefore, that seed stocks be isolated and aphids controlled.

Mild Mosaic

Mild mosaic, a disease common in all potato-growing districts, is among those most difficult to recognize where bright sunlight and high temperatures prevail during the growing season. In prolonged dry spells with high temperatures, its symptoms are so inconspicuous that detection in the field is almost impossible. Cloudiness aids greatly in observing it. The chief symptom is a leaf mottling in which light-green or yellowish areas alternate with those of normal green (fig. 16). The mottled leaves are often slightly crinkled. Diseased plants often die prematurely.

The best way to avoid mild mosaic is to select seed tubers from healthy plants. Using isolated seed plots and planting by the tuber-unit method aid greatly in eliminating the disease. Whenever a plant shows definite symptoms of mild mosaic, all other plants grown from the same tuber should be rogued out with it. The virus is spread by aphids, and control of these insects is essential to control of the disease.

Varieties showing greater or less resistance to mild mosaic, some of which have in some instances proved immune in the field, include Katahdin, Chippewa, Houma, Sebago, Red Warba, Earlaine, DeSoto, Calrose, Mohawk, Teton, Kennebec, and Yampa.

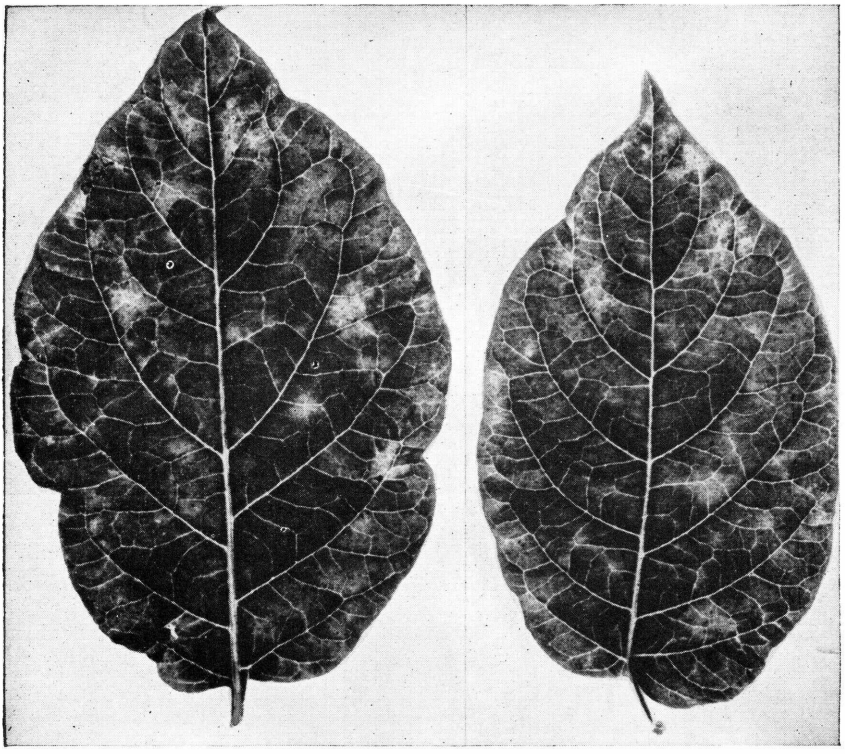

Figure 16.—Leaflets from a Green Mountain potato plant affected with mild mosaic. Light-green or yellow patches scattered over the leaves are the chief symptom of this virus disease.

Rugose Mosaic

Rugose mosaic is a more serious disease than mild mosaic but is easier to detect. The mottled leaf areas are smaller, more numerous, and usually closer to the veins than in mild mosaic. The mottling may be inconspicuous in hot weather, but the crinkling of the leaves is not. Veins on the under sides of the lower leaves often show dead areas resembling black lines drawn with a pencil. Most infected plants are stunted and die prematurely. Yellowing and subsequent dropping of the lower leaves are symptoms of infection from some source other than the tuber (fig. 17). If infection occurs late in the growing season, typical symptoms may not appear but the tubers will carry the infection and plants grown from them will be typically affected. Aphids spread the disease from infected to healthy plants. Most successful control depends upon careful roguing, started when the plants are 2 to 3 inches high and repeated every 7 to 10 days until midseason.

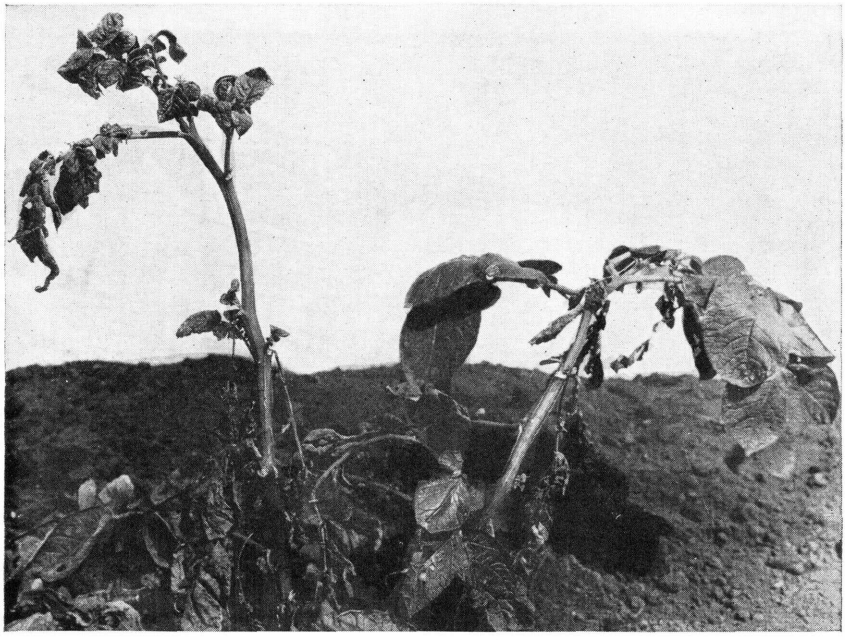

Figure 17.—Yellowing and dropping of lower leaves of this plant showed that it was infected with the rugose mosaic virus otherwise than from the seed tuber.

No potato variety has been found immune from this disease; but some varieties, such as Chippewa and Katahdin, contract it less easily than others.

Leaf Roll

The name "leaf roll" indicates the main symptom of the disease to which it is applied. In most varieties the first symptoms become noticeable about a month after the plants appear above ground. The leaflets of the lower leaves roll up at the edges and become leathery.

As the plant grows, such rolling usually appears on higher and higher leaves until it affects practically the whole plant (fig. 18). The rolled leaves are lighter in color than healthy ones and become brittle. A reddish or purple discoloration of the under sides of leaves is characteristic of the disease on some varieties.

Figure 18.—Spaulding Rose potato plant affected with leaf roll.

Net necrosis is a symptom of leaf roll on certain varieties, appearing in tubers of plants that become infected otherwise than from the seed tubers. This is a network of brown strands of dead tissue extending throughout the stem end of the tuber.

The tubers of plants affected with leaf roll are small but usually of normal shape. The disease often reduces the yield by half.

Leaf roll virus is spread from plant to plant by aphids. Control of these insects in seed fields is essential to control of the disease. If the virus is spread by aphids late in the season, the newly infected plants do not show typical symptoms; but their tubers, if used for seed, will produce diseased plants.

Only certified seed stock from plantings known to be free from leaf roll should be used. Growers of certified seed are giving careful attention to the disease, and dependable certified seed is good insurance against it.

Spindle Tuber

The name "spindle tuber" indicates the common tuber symptom of the disease to which it is applied; affected tubers of most varieties have the spindle shape shown in figure 19. The eyes are shallower and more numerous than normal. Affected tubers of Triumph are longer than normal and usually lighter in color, but do not always have the spindle shape. The diseased plants show up very strikingly in the field, being more erect and spindling and having darker foliage than healthy ones. At high temperatures the symptoms become more conspicuous.

This disease is very common in the western potato-growing districts. It causes marked reductions in yield, and in severe cases its effect on the shape of tubers may keep them out of any but the low commercial grades. The disease is readily transmitted by certain insects, such as grasshoppers, flea beetles, the tarnished plant bug, and the Colorado potato beetle, and is spread also by cutting knives and picker planters. It can be controlled by using good certified seed and roguing tuber-unit seed plots early in the season.

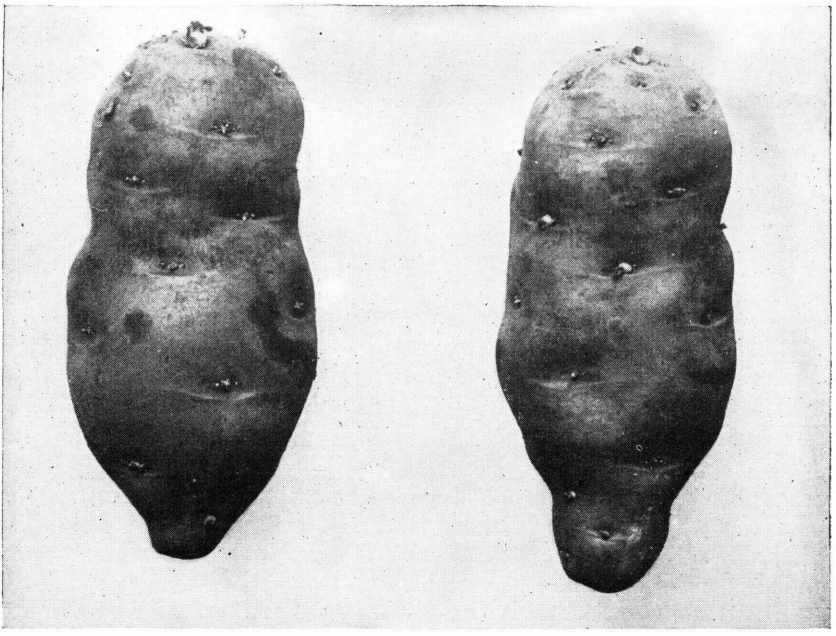

Figure 19.—The shape of these tubers is the characteristic symptom of the disease called spindle tuber.

Calico

Calico, one of the mosaic diseases, occurs commonly in potato fields, often on scattered plants only. It causes large, irregular yellow to cream-colored areas on the leaves. In most cases no tuber from an infected hill will produce plants free from the calico symptoms. Roguing affected plants during the growing season effectively controls the disease.

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Witches'-Broom

Witches'-broom, an uncommon disease, seems to occur chiefly in the Pacific Northwest. A diseased plant has many slender, spindly stems, none of which appear normal; usually has small, velvety leaves; and seldom grows taller than 9 inches (fig. 20). The affected plants produce many small potatoes, and these often produce large numbers of spindling sprouts.

How this disease is spread has not been discovered. It can be controlled by selecting seed tubers from healthy stock and roguing.

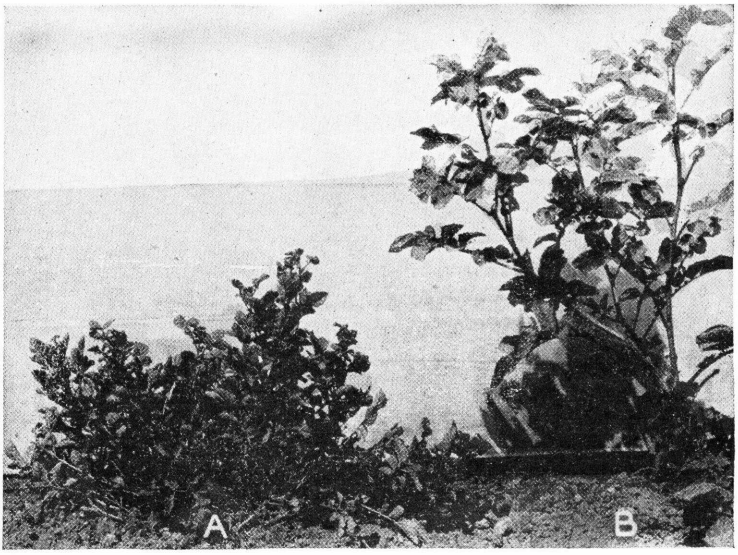

Figure 20.—A, Triumph potato plant, grown from a tuber severely affected with witches'-broom, exhibiting the numerous short, spindly stems and the small leaves typical of the disease; *B,* healthy plant of the same variety.

Haywire

Haywire is a disease that in some of its symptoms resembles leaf roll and psyllid yellows. In some cases the symptoms may be mistaken for those of rhizoctonia canker. Haywire has been found for years in Nebraska and Colorado. It is usually more serious in high mountain valleys and on high plateaus than elsewhere. It does not appear to increase rapidly and usually affects only scattered plants in the field. In some fields, however, it has affected as many as 20 percent of the plants. This disease has two types of characteristic symptoms: (1) Extreme dwarfing and curling of plants when they emerge from the soil, and (2) curling and yellowing of the top leaves about midseason. Plants showing either of these types of symptoms have purple discolorations at the margins of leaves, on petioles, and on stems and have swollen nodes. A plant that shows characteristic symptoms of haywire when it emerges from the soil will produce only very small tubers, weighing less than one-half ounce each, set close to the stem at the soil line. When symptoms appear about midseason, 1- to 2-ounce tubers sometimes develop. These are likely to show net necrosis, and they seldom sprout.

All evidence indicates that a virus causes this disease and that some insect transmits the virus. Plants found showing haywire symptoms should be removed from the field immediately.

Psyllid Yellows

Psyllid yellows, a disease peculiar to the West, is most serious in Colorado, Wyoming, western Nebraska, New Mexico, and Utah. In Colorado it often becomes epidemic; during 1930 and 1931 it practically eliminated the early-crop potatoes in several Colorado districts. Psyllid yellows is caused by a toxic substance introduced by nymphs of the potato psyllid during feeding. (Apparently this substance is never introduced by adult insects.) Although not definitely known to be caused by a virus, this disease resembles those that are known to be virus-caused in that it affects the whole plant and involves a complete upset in the plant's metabolism.

The first symptoms are yellowing of the margins and upward rolling of the basal portions of the smaller leaflets on the young leaves. Typically, the rolled leaves turn a reddish yellow. Those of some potato varieties turn purple. The older leaves of an affected plant roll upward over their midribs. After that, the whole plant appears reddish yellow or purplish, and buds both above and below the ground become active. Above ground, axillary buds may develop into stalky shoots that frequently branch and give the plant a compact pyramidal shape (fig. 21). In some cases the axillary buds develop into aerial tubers, which become numerous in the later stages, and the older leaves die.

Psyllid yellows causes a potato plant to produce an abnormally large number of tubers; a seriously affected plant may have as many as 100. Several tubers may develop along a single stolon, with the result that many small tubers are produced. A plant on which psyllids feed before it sets tubers practically always produces a large number of tubers too small to be marketed. Many of these sprout and produce new plants before the mother plant dies. Plants grown from the diseased tubers are smaller and less vigorous than normal, but they do not show the leaf rolling or other symptoms of psyllid yellows.

Psyllid yellows can be controlled effectively by spraying with 1-to-40 lime-sulfur, by dusting with sulfur, or by dusting or spraying with DDT. All surfaces of the tops must be covered. In general, spraying or dusting should begin when the first adult psyllids appear or when the plants are 4 to 6 inches high. Getting thorough coverage with a spray is easiest when the plants are small.

Because psyllids lay their eggs on the under sides of the lowest leaves, many types of spray equipment are not well adapted for control of the insects. The nozzles should be so placed that the spray can be directed down into the row and also upward, at both sides of the row, from near the bases of the plants. The side nozzles are so adjusted that they are slightly offset and thus tend to give the spray a swirling motion. This makes it possible to cover all surfaces. A pressure of 400 to 600 pounds is desirable.

The number of sprayings or dustings needed depends on how many psyllids are present. Usually three sprayings 7 to 10 days apart are

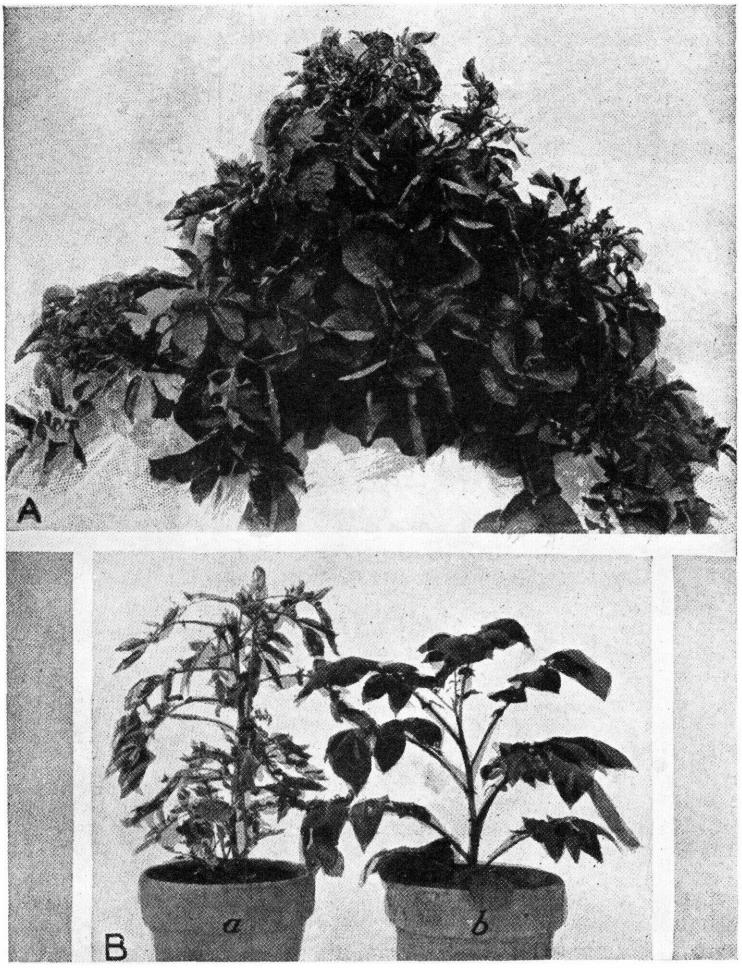

Figure 21.—Psyllid yellows in potato plants of the Irish Cobbler variety. *A*, Diseased plant exhibiting characteristic pyramidal shape, upward rolling of older leaves, and secondary growth of curled leaves at tips of branches. *B*, Plant affected with psyllid yellows (*a*) in contrast with healthy plant (*b*). Leaf rolling is pronounced, and aerial tubers have appeared in axils of leaves.

required; often a fourth or even a fifth is required if the infestation becomes severe.

Purple-Top Wilt

Purple-top wilt is less prevalent in the West than in the North Central States. Experiments in Minnesota, New York, and West Virginia seemed to indicate that this disease is due to the virus that causes aster yellows, and that this virus is carried by the six-spotted leafhopper. In advanced stages of the disease, the above-ground symptoms resemble those of psyllid yellows but the tuber symptoms do not.

The first symptoms appear at the tip of the plant. The young leaves do not grow normally, and the leaflets roll upward. In potato varie-

ties that normally have reddish coloring, a reddish-purple color appears on the foliage and, particularly, the stems of diseased plants. In other varieties a light-green or yellowish cast often appears. Often axillary shoots develop in abnormal numbers and eventually show the symptoms just mentioned. These shoots become swollen at the base, and often distinct aerial tubers form on them (fig. 22).

Figure 22.—Katahdin potato plant showing leaf rolling and wilting characteristic of purple-top wilt. The branch at the left is still healthy.

The vascular tissue (tissue forming vessels that carry sap) of the stems turns brown when the foliage symptoms appear, the abnormal color usually extending well into the stolons. The plants wilt within 2 weeks after symptoms appear, and may soon die. When affected plants are killed by frost, their stems usually turn black.

Internal necrosis (dying of certain internal tissues) of tubers is typical of purple-top wilt in the Rural New Yorker No. 2 variety in West Virginia, but not in that or other varieties in Minnesota and other States. Occasionally tubers from diseased plants are flabby. Number of tubers is not abnormally large as it is in psyllid yellows.

Purple-top wilt is not known to be transmitted by the tubers, but plants grown from tubers of the diseased plants are below normal in vigor. Because tubers from the diseased plants produce only spindling sprouts, most of them can be detected if they are allowed to sprout before planting.

Common Scab

Common scab of potatoes is caused by a soil organism (*Streptomyces scabies*) that lives and increases on growing tubers and also lives from season to season on dead plant material in the soil. Spots resembling scabs appear on the affected tubers (fig. 23). These spots may be sunken below the surface of the tuber, either shallowly or deeply, or raised above it. There are a great many different races of the organism, some of which have different effects on potatoes of different varieties. Most agricultural soils harbor at least one of these races, and one soil may harbor several of them. Potato varieties that are usually susceptible to scab do not become infected with it in some soils that contain the scab organism. It has not been fully explained whether this is due to differences among potato varieties in susceptibility to individual races of the scab organism, to soil differences, or to some other cause.

Factors affecting the danger of scab injury to potatoes include soil reaction (alkalinity or acidity), soil aeration, and soil moisture. Scab is often serious in alkaline soils—a class that includes most of the soils of the West. Sometimes it occurs in soils that are slightly, moderately, or even highly acid. Potatoes grown in peat soils, which are well aerated even when wet, are often seriously injured by scab—particularly where the peat contains much lime.

Scab infection in a normally alkaline soil can sometimes be reduced by making the soil acid, but no practical method has been found for bringing about this change in a soil that is highly alkaline. Adding sulfur to alkaline soil has reduced scab infection in a very few cases

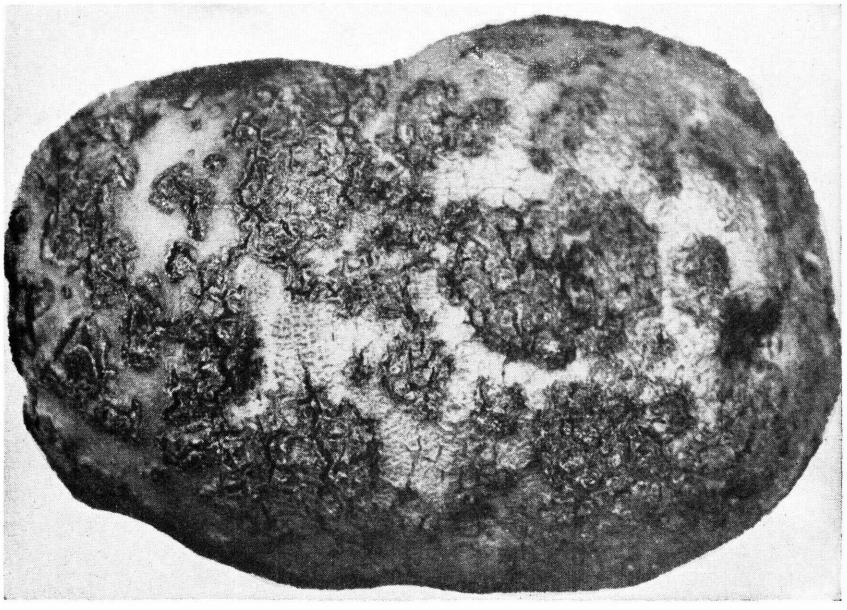

Figure 23.—A potato tuber severely affected with common scab.

only. The acidifying power of sulfur varies greatly with the amount of alkaline salts present in the soil and with the soil's moisture content. In most of the western potato-growing districts, the large amount of sulfur required to acidify the soil would probably make such treatment too expensive. Also, heavy applications of sulfur to the soil may cause root damage.

Scab cannot be controlled dependably by disinfecting seed, because of the presence of the scab organism in most agricultural soils. Planting clean seed in infested soil often leads to production of a crop of tubers as scabby as those produced by planting scabby seed. By disinfecting his seed, however, a grower may avoid introducing to his soil one or more races of the scab organism that are not already present in it.

Scab has not been controlled effectively through crop rotation. A crop of potatoes may be heavily infected with scab even though produced in a field where potatoes were never grown before. However, scab infection tends to be more severe where potatoes have been grown for several years on the same soil.

The United States Department of Agriculture and cooperating State agencies are devoting much effort to developing potato varieties that will resist scab. Several late-maturing resistant varieties have been developed and are being grown with considerable success. These include Menominee, Ontario, Seneca, Cayuga, and Yampa.

The shallow type of scab does not seriously affect the eating quality of potatoes, and consumers should not reject tubers having scab of this type.

Leak

A watery rot of the potato tuber called leak (fig. 24) is caused by the soil fungus *Pythium ultimum* and probably also by several species of *Phytophthora* closely related to the fungus that causes late blight. Externally an affected tuber may show discoloration ranging from metallic gray in red varieties to brown in white- and dark-skinned varieties. The internal tissues affected are creamy at first but soon turn reddish, then brown, and finally black. When pressure is applied to the tissues, a yellowish to brown liquid appears.

Infection usually occurs in the field. Probably the causal fungus can enter the tubers either through wounds or through eyes. Sunburn and sunscald at time of harvest may make infection easier. Effective control measures are not known. Careful handling at time of harvest tends to prevent infections that would develop in storage.

Jelly-End Rot

Jelly-end rot is a potato disease caused by one of the *Fusarium* fungi. It occurs rather commonly on the Pacific coast, particularly on long varieties such as Russet Burbank. Generally it affects the stem end of the tuber. In severe cases the affected part or parts become jelly-like; in mild cases they only wither slightly. When infected tubers are placed in storage, the disease makes no further progress and the affected part often dries up (fig. 25). A sharp line divides the dried from the healthy tissue.

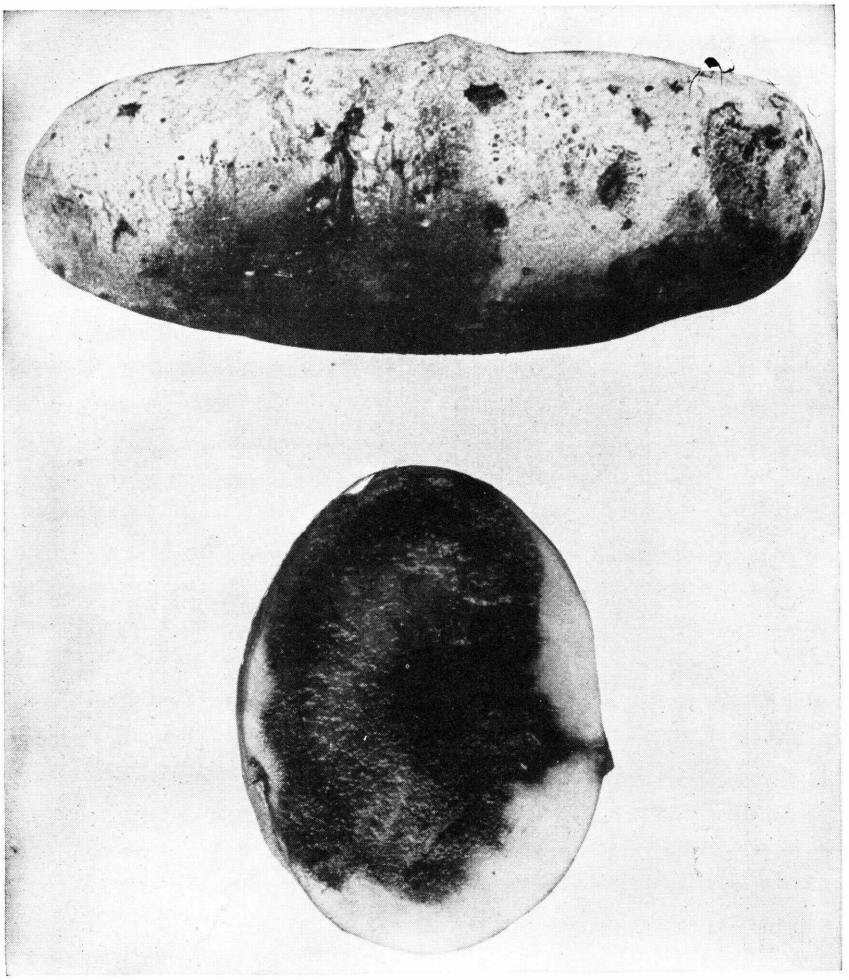

Figure 24.—Potatoes affected with the watery rot called leak.

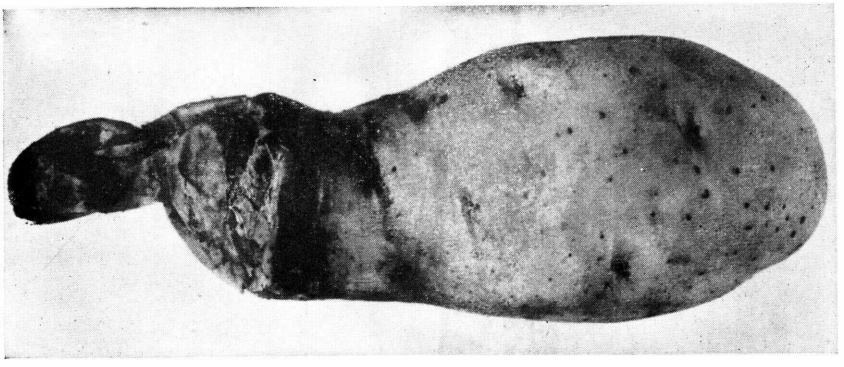

Figure 25.—Russet Burbank potato affected with jelly-end rot. The diseased tissues, after first becoming jellylike, have dried up in storage.

No measures can definitely be recommended for control of jelly-end rot. Maintaining an even, adequate supply of soil moisture throughout the season may help.

Rhizoctonia Canker (Black Scurf)

Rhizoctonia canker, or black scurf, is caused by the fungus *Rhizoctonia solani*. Under conditions that favor its development, this fungus may cause serious damage to underground stems and stolons of the potato plant.

Potato plants infected by *Rhizoctonia* are characterized by curling and purpling of the leaves in severe attacks and by general lack of vigor in mild ones. When the underground portion of a stem is only partly girdled by the fungus, few top symptoms appear. When it is completely girdled, the top symptoms resemble those of psyllid yellows; the foliage curls and turns pinkish to purplish, and often aerial tubers are formed. Either complete or partial girdling reduces the number of normal-size tubers produced or limits the plant's yield to a few small tubers close to the surface of the soil. Stem lesions occur most commonly when soil is below 70° F. and rather moist. When stolons are attacked and the stem is not, top symptoms may not appear but the number of tubers is reduced.

The most common symptom of rhizoctonia canker is development of sclerotia (fig. 26), irregular small jet-black masses, on the skin of mature tubers. These masses can be mistaken for soil until it is found that they do not wash off. They are made up of threads of the *Rhizoctonia* fungus. They do no harm to the tuber, except that they detract

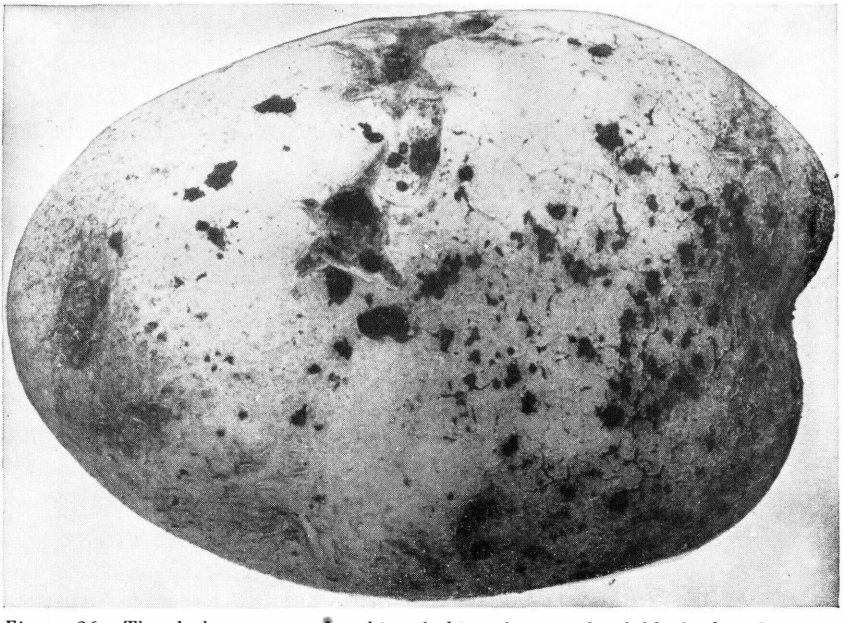

Figure 26.—The dark spots on the skin of this tuber are hard black thread masses (sclerotia) of the fungus that causes rhizoctonia canker, or black scurf.

from its appearance; but when infected tubers are used for seed, threads from the sclerotia infect shoots, roots, and other parts of the growing plants.

The *Rhizoctonia* fungus, like the common scab organism, can live over winter in the soil. It seems to do this less readily in some soils than in others, and apparently it is absent from some soils.

Seed potatoes showing the sclerotia should be treated by one of the disinfecting methods recommended (pp. 5–7). Even if the seed is to be planted in contaminated soil, such treatment offers some protection to the young sprouts. In cool, moist soils, shallow planting aids in preventing stem lesions, because the soil nearest the surface warms up faster in spring. As the season progresses, shallowly planted seed can be covered deeper each time the soil is cultivated.

Late Blight

Late blight of potatoes, caused by the fungus *Phytophthora infestans*, although generally less destructive in the West than in the New England and North Central States, has caused serious losses along the Pacific coast. It has done some damage also on irrigated lands in northern Colorado and in other parts of the Rocky Mountain region. This disease is so named because the fungus causing it usually attacks potato plants at or after the blooming stage. The attack may take place at any stage of growth, however.

The first symptom of late blight is purplish or brownish-black areas on the blade of the leaflet, the leafstalk, the flower stalk, or the stem. Usually the lower leaves are the first to show the infection. Recently invaded areas form light-colored, water-soaked margins around areas that have already been turned black by the disease. They, in their turn, blacken and die. In warm, moist weather, the disease spreads rapidly and all the plants in a field may be killed within a few days. The diseased and decaying plants have a characteristic odor, which becomes very noticeable in fields where the attack has been heavy.

The fungus causing late blight attacks not only potato tops but the tubers in the soil. The tuber rot, brown in color, spreads irregularly from the surface through the flesh. The diseased tissue may remain firm or may soften as a result of secondary infection with soft rot organisms. On potatoes in low-temperature storage, the disease is typically dry rot, which affects irregular areas and may involve the whole tuber if humidity is high and temperature is favorable.

On parts of potato leaves that have become infected with the fungus causing late blight, many small spores of the fungus develop. These spores may be washed from the leaves and into the soil by rain. On irrigated areas they are very likely to drop into irrigation water, float in it down the rows, come to rest on the soil, and infect tubers. Where even a few plants in a field have become infected with this fungus, the grower should avoid irrigating while the spores are being produced and are dropping—that is, at night and in early morning. It is better to stop irrigating entirely when the infection on the leaves is developing actively. If the disease appears when the tubers are almost mature, irrigation should be stopped for the season. If it appears before the tubers have reached medium size and when irrigation is necessary to produce a crop, water should be applied only after

the plants have been thoroughly sprayed or dusted with bordeaux mixture, by methods described on pages 46 and 47 of this bulletin.

Digging of potatoes in fields infected with late blight should be postponed until all the infected plants have been dead for 10 days to 2 weeks, or for a little less than 10 days if the soil is dry at digging time.

Potatoes affected with late blight should not be used for seed. Seed pieces from the affected tubers often fail to sprout, and they may produce diseased plants from which infection may spread over entire fields. Infected tubers should not be dumped in piles at the edges of fields or along roads, where infection could spread from them the following season. If tubers affected with late blight happen to remain in or near a field over winter, they should be destroyed before any potato plants of a new crop come above the ground.

Many of the older potato varieties are susceptible to late blight. Several resistant varieties have been developed: Kennebec, Sebago, Menominee, Potomac, and Calrose. The variety Kennebec is resistant to both vine and tuber infection.

Fusarium Wilt

Fusarium wilt, caused by several species of *Fusarium* fungus, is one of the most common diseases of potatoes in the West, especially on irrigated lands having warm soils.

In the type of wilt caused by *Fusarium oxysporum*, wilting is accompanied by yellowing of the lower leaves. This fungus lives in the soil, and infection with it is favored by high soil temperatures. Another species, *F. eumartii*, causes a more rapidly developing type of wilt in which the tops become discolored and flecks appear in the stem pith. Both these types of wilt lead to premature death of the plant. Either fungus may infect the lower stem, roots, and stolons and may enter the tubers through the stolons. Stem-end tissues of infected tubers darken to a distinctly brown color (fig. 27). Even if the fungus threads do not actually get into the tuber tissue, such discoloration may result when rapid killing of the stolon causes collapse of the stem-end tissues of the tuber.

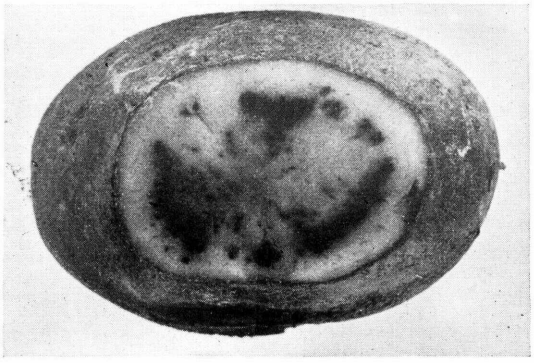

Figure 27.—Stem-end tissues of this tuber exhibit the brown discoloration caused by fusarium wilt.

In most potato-growing districts of the West, fusarium wilt can be greatly reduced by keeping potato plants in vigorous growing condition through careful management of irrigation. The plants should never be allowed to wilt because of lack of soil moisture, for *Fusarium* fungi readily infect roots and stolons of wilted plants. Control of these fungi is difficult, because they overwinter in the soil and also may be carried over in tubers.

Verticillium Wilt

Verticillium wilt, a disease caused by the soil-borne fungus *Verticillium alboatrum*, is causing considerable losses of potatoes in some parts of Idaho, Washington, and California. It shows up earlier in years when unusually warm weather occurs early in the growing season. Once this disease has shown up in a field, it cannot be controlled effectively by any method now known. Yields from infected fields can be increased by anything that increases soil fertility. Rotations including 3 years of alfalfa seem to be of some benefit, perhaps because they increase soil fertility.

Ring Rot (Bacterial Ring Rot)

Ring rot is caused by the bacterial organism *Corynebacterium sepedonicum*. It appeared in potato fields of the United States about 1934 and now occurs in practically all the potato-growing States.

The top symptom of the disease is wilting of stems, branches, and leaves (fig. 28). This does not become evident until late in the growing season. Some infected plants never show top symptoms. Sometimes only one stem or only parts of the stems in a hill show wilt, the rest continuing to look healthy.

When affected plants are dug, usually some of the tubers look completely sound and others show all stages of decay. Tubers that look sound may nevertheless be infected. The decay is most evident near the vascular ring. It may affect any part or the whole of this ring. The decayed tissue is yellowish white and of a crumbly nature (fig. 29). Squeezing an affected tuber in the hand may force this decayed material from the ring. Severely infected tubers may crack or show a reddish discoloration of the skin. Soft rot organisms often invade tubers infected with ring rot and cause them to break down completely.

Because tubers infected with ring rot may show no symptoms, it is hard to make sure that seed is not infected. Even a slightly infected tuber contains bacteria sufficient to contaminate healthy tubers either through direct contact or by way of the cutting knife.

Every effort should be made to control ring rot by using uninfected seed. A potato storage house or cellar should be disinfected every year it is used, especially if it is used for storing seed. Knives used in cutting seed potatoes should be disinfected. Stationary blades may be disinfected with a continuous flow of a 1-to-500 solution of mercuric chloride, and rotary blades with that solution or with boiling water.

(See warning, p. 6.)

Teton, a recently introduced potato variety, does not readily become infected with ring rot. It seldom shows either tuber or top

symptoms, but it may carry the disease organism without showing symptoms.

The ring rot organism is not known to live from one season to another in the soil.

Figure 28.—The wilting of the branches and leaves of this potato plant resulted from ring rot. (Courtesy of Florida Agricultural Experiment Station.)

Early Blight

Early blight, a potato disease caused by the fungus *Alternaria solani*, is very common in many of the Western States. In some years this fungus does considerable damage by causing potato leaves to die prematurely. It produces scattered small targetlike spots on the potato leaf. These spots often become yellow, and many enlarge till they cover a large part of the leaf. Usually the fungus attacks the leaves 2 or 3 weeks before harvest. Occasionally, when showers occur during warm weather, it attacks the tubers, causing a light-brown

Figure 29.—Lengthwise slicing of this tuber revealed that ring rot had separated the outer ring of tissue from the core. (Courtesy of Florida Agricultural Experiment Station.)

surface rot through which secondary soil-inhabiting fungi may enter. Spraying with bordeaux mixture controls early blight to some extent. Spraying with Dithane or some other preparation of zineb has given good results in Colorado.

Blackleg

Blackleg, a disease caused by the bacterium *Erwinia phytophthora*, causes heavy losses in some western potato-growing areas. Characteristic field symptoms, which may be noticed when the plants are only a few inches high, are yellowing and severe rolling of the leaves. As the disease progresses, dark and often slimy lesions extend up the stems for some distance above ground level. Plants having such stem lesions usually die before setting tubers. In plants infected from the seed, the disease appears early. Occasionally the first symptom is lesions on the above-ground part of the stem. In such a case, usually the bacteria have entered the stem through an injury. Sometimes operation of spraying and cultivating equipment has a part in this sort of infection. Plants that become infected when very young set few, if any, tubers. If infection occurs after tubers have formed, the bacteria may enter the tubers by way of the stolons and may cause their stem ends to rot.

The bacteria may be carried in tubers, without causing tuber symptoms, and either cause seed pieces to rot before producing plants or produce the disease in plants grown from them. More commonly, seed pieces that were free from the infection when planted are entered

by bacteria in the soil. The bacteria can be carried into planted seed pieces by the seed-corn maggot. When the adult of this insect, a fly, lays its eggs on or near infected seed pieces, the maggots hatching from the eggs are likely to carry the bacteria to uninfected seed pieces.

Blackleg is extremely hard to control. The most effective control measure is to use clean whole seed. Cut seed is less likely to be entered by soil-borne bacteria if it becomes well "corked over" before being planted. Seed treatment has not proved dependable as a method of controlling this disease; although it may kill bacteria on the surface of a tuber, it does not protect the seed pieces from soil-borne bacteria. No resistant varieties have been developed.

Spraying and Dusting

As a spray for controlling some of the leaf diseases of potatoes, 4–4–50 bordeaux mixture has given the best results. Calcium arsenate or zinc arsenite is added when needed for control of the Colorado potato beetle and flea beetles (discussed later under the heading "Insects and Their Control").

(See warning, p. 53.)

The materials required for making 4–4–50 bordeaux mixture are pulverized copper sulfate, 4 pounds; lump lime, 4 pounds, or hydrated lime, 6 pounds; and water, 50 gallons. A convenient method of making up this spray mixture is to dissolve the copper sulfate in 25 gallons of cold water, either suspending it in a sack near the surface of the water overnight or using first a small quantity of hot water; to slake the 4 pounds of lump lime gradually with a small amount of water and dilute the product to 25 gallons, or mix the 6 pounds of hydrated lime in 25 gallons of water; and then to pour the two preparations together and stir vigorously. The resulting bordeaux mixture is milky blue. If the spray mixture cannot be used at once, three-fourths ounce (a heaping tablespoonful) of sugar dissolved in a little water should be added to each 50 gallons of the mixture. This addition will keep the mixture in good condition for a long time; without it, the spray would become worthless after about 24 hours.

To be most effective, spraying for disease control must sometimes start when the plants are 4 to 6 inches high and continue at regular intervals throughout the growing season. In some years and some localities, 5 or 6 applications are enough. At other times and places, 10 to 12 sprayings a year are needed. In dry years spraying may be unnecessary, at least until disease appears. Growers should consult their State agricultural colleges or local extension services in order to fit their spray programs to local conditions.

It is good practice to spray all new growth as it appears and to spray again when the growth becomes older. To give the vines a good protective coating, it is necessary to apply 60 to 75 gallons per acre when the plants are small and 100 to 125 gallons per acre when they are large.

Dusting is preferred by many growers as a method for controlling foliage diseases of potatoes, because dusts are easier to apply than sprays and can be applied with less expensive equipment. The right dusts, efficiently applied under favorable conditions, give results as good as those obtained by spraying. If dusts are applied when air

movement will cause them to drift or rise, best results cannot be expected.

Many fungicidal dusts are now on the market. Most of these can be used in mixture with DDT. In addition to dusts sold under trade names, a mixture of monohydrated copper sulfate and hydrated lime still finds favor in some districts.

How much dust is needed depends on the size of the plants and the percentage of copper in the dust. Generally, the number of applications needed during a season is the same for dust as for spray. When the copper-lime dust comes into contact with moisture on the leaf, the particles of copper sulfate and lime combine to form a bordeaux mixture. It is desirable to apply the dust early in the morning when the leaves are covered with dew, in order that this combination may take place and because otherwise the dust is likely to blow off.

Whatever dust is used should be so applied that it will cover the plants thoroughly.

OTHER DISEASES

Several diseases of potatoes are or appear to be related to unfavorable environmental conditions and not to be caused by any virus, fungus, bacterium, or insect.

Internal Brown Spot

Internal brown spot of potato tubers is common in some seasons. Dry brown spots appear scattered through the flesh of the tuber (fig. 30). These spots are dead cells, free from bacteria and fungi. No

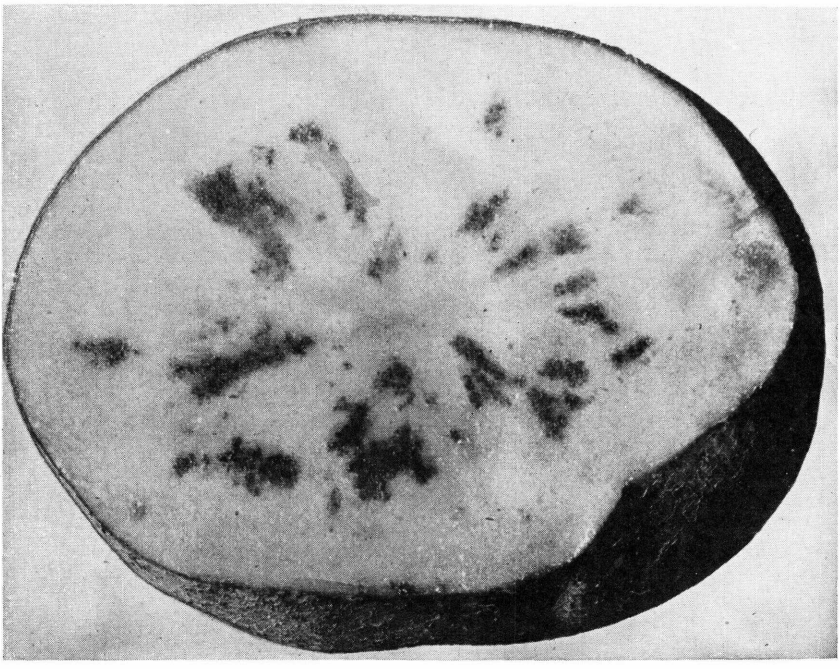

Figure 30.—A potato affected with internal brown spot.

definite foliage symptoms have been found associated with this disease. There is some evidence that lack of available moisture near the end of the growing season may contribute to it.

Tubers affected with internal brown spot should not be used for seed, as they are likely not to produce strong plants.

Sunburn and Sunscald

Sunburn, or greening, and sunscald are caused by exposure of tubers to sunlight or high temperatures during growth or after digging, either in the field or in transit or storage.

Sunburn does not involve killing of the affected tissues, but sunscald frequently does. Often sunscalded tubers become watery and turn brown to a considerable depth or throughout. Sometimes freshly scalded surfaces have a blistered appearance and a metallic color and the underlying tissues are rather watery. When such surfaces dry out, they may appear either chalky and granular or hard and leathery. They are usually attacked by bacteria that cause foul-smelling rots or by the fungus that causes leak.

The one way to control sunburn and sunscald is to prevent long exposure of tubers to sunshine and high temperatures.

Heat and Drought Necrosis

Necrosis (dying of tissues) caused by heat or drought is rather common in potatoes grown in the light sandy soils of the West. In Idaho and Colorado this condition becomes common when tubers are allowed to remain in the hot soil after the vines have died. It is characterized by a yellowish-brown discoloration of water vessels and is most noticeable near the ends of the tuber. Sometimes the whole interior of the tuber is involved. The white-skinned varieties are more susceptible than the red-skinned. Control consists mainly in keeping the soil moist and cool and digging the tubers as soon as the tops start to die.

Spindling Sprout

Spindling sprout, or hair sprout, is a constitutional weakness of the potato tuber that causes sprouts to be abnormally slender and feeble (fig. 31). Some of the sprouts from seed pieces of tubers having this weakness are only about one-half to one-fourth as large in diameter as normal ones. Plants developing from such sprouts bear only small tubers weighing an ounce or less. When these tubers are planted, however, they produce stocky, vigorous shoots, which develop into plants that bear normal tubers weighing 5 to 7 ounces.

Sprouts produced by tubers having spindling sprout are similar in appearance to those produced by plants having witches'-broom. Potatoes affected with the two diseases should not be confused.

It has been suggested that before planting seed produced where spindling sprout has been prevalent, the potato grower should sprout some of it to find whether the disease is present.

Blackheart

Blackheart is a disease resulting from asphyxiation of the tissues of potato tubers. It occurs when tubers are subjected to very high

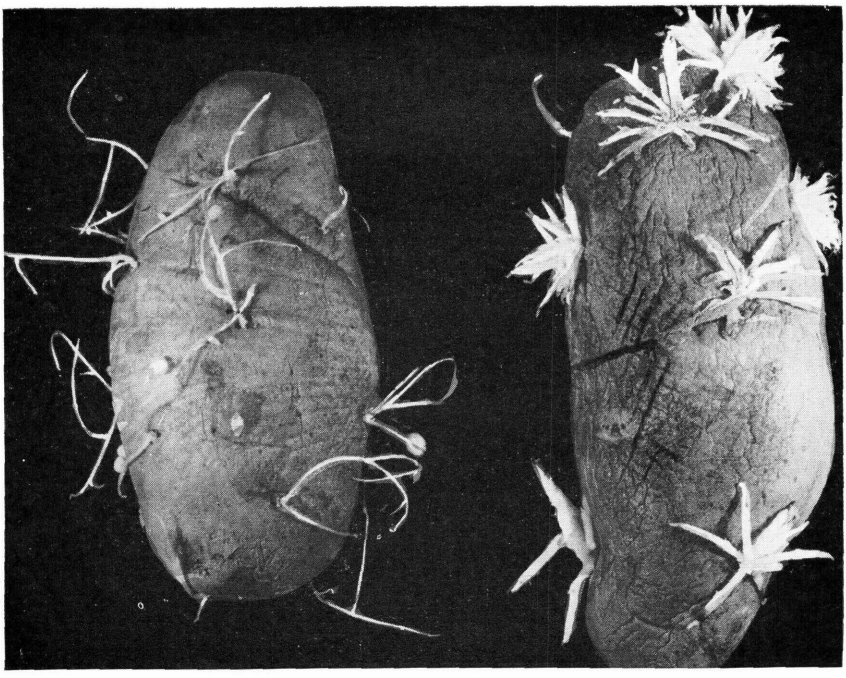

Figure 31.—White Rose tuber (left) producing the slender, feeble sprouts characteristic of the disease called spindling sprout, in contrast with a healthy tuber of the same crop.

temperatures or to ventilation so poor that the air does not contain enough oxygen, or under combinations of such conditions.

The external symptom is discolored areas, sometimes moist. These may be purplish for a short time at first, but characteristically are brown or black. The internal symptom is a dark discoloration (fig. 32), grayish to purplish or inky black. Generally this is restricted to the heart of the tuber, but frequently it radiates to the skin. It may appear in zones in the outer parts of the tuber and be absent or less conspicuous at the center. The discolored tissues are usually set off sharply from the healthy ones. They are firm and even leathery if they have dried out a little; in this they differ strikingly from those of potatoes affected with leak, which frequently show similar colors. In advanced stages the affected tissues dry out and shrink, which causes formation of cavities.

Tissues exposed by cutting soon after injury are of normal color; shortly after exposure to air, however, they turn pink, then gray, purplish, or brown, and finally jet black. Sometimes all these colors except the pink are found simultaneously in the same tuber. At other times only gray or brown is found; such is the case when tubers have been heated above 130° F. or when they have been deprived of all oxygen for considerable periods, as in waterlogged soils or in flooded storage pits.

Asphyxiated tissues are easily invaded by bacteria and fungi. These cause watery or slimy decay, which soon hides the typical black-heart symptoms.

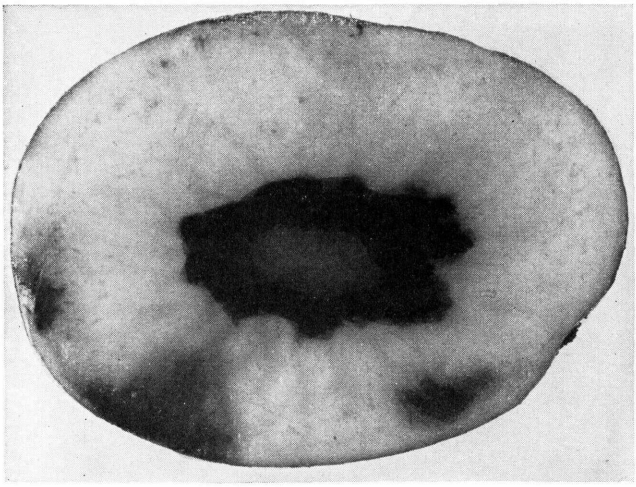

Figure 32.—Section of a potato showing blackheart.

Control involves avoiding high storage temperatures and providing for good ventilation of storages. Tubers will not develop blackheart at temperatures below 95° F. where there is a good supply of air. The temperatures in heated cars should not be allowed to go above 60° or 70°. To prevent oxygen shortages, tubers should not be stored in solid piles more than 6 feet high, even at low temperatures. They should not be left long in hot, light soils after the vines die, and should not be left lying on the soil surface after being dug during hot weather.

Hollow Heart

Hollow heart is a more or less irregular cavity in the center of the tuber. Usually the surrounding tissues show no discoloration; occasionally they assume a brownish, corky appearance. This abnormal condition is commonly confined to large tubers and occurs mainly under conditions favorable for rapid growth. Hollow heart is not a decay and has no effect on plants grown from the affected tubers. Obviously, it makes stock undesirable for eating.

Where potatoes are likely to grow too large, hollow heart can be very largely if not entirely avoided by closer spacing of the plants. Such spacing prevents rapid and uneven growth of the tubers and thus tends to prevent internal splitting.

Enlarged Lenticels

The lenticels, or natural pores, of potato tubers, ordinarily inconspicuous slits at the surface, sometimes become enlarged when the soil of the potato field is very wet for a long time. The same thing sometimes results when the tubers are stored in a very moist atmosphere. Tissue around many of the small openings becomes raised, looking as if pushed out from below, and frequently this tissue takes on a corky appearance.

Second Growth (Knobby Tubers)

A condition known as second growth or knobby tubers is often produced in potatoes when dry weather prevails during midseason and is followed by a rainy spell. Tuber growth, after temporarily ceasing in the dry weather, begins again after the rain, and this causes knobs to appear on various parts of tubers (fig. 33). Sometimes the affected tubers have pointed ends. This trouble may result also from irregular irrigation. Some potato varieties, especially among those having long tubers, are more inclined to second growth than others.

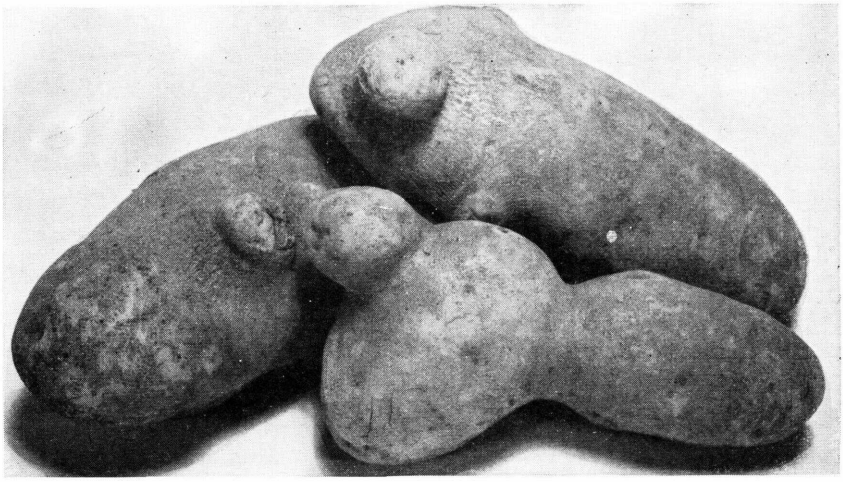

Figure 33.—The knobby shape of these tubers, called second growth, resulted from midseason drought followed by a rainy spell.

Freezing Injury

Freezing injury of potato tubers occurs when the tubers are exposed to temperatures low enough to cause ice to form in their tissues. Symptoms of freezing appear only when the tubers have thawed.

Tissues killed by freezing look wet when they thaw, and usually become infected with bacteria. If the tissues thaw in a warm and humid atmosphere the bacteria cause a wet, slimy rot; if they thaw slowly in cool, dry air, they may dry to a mealy mass or to a tough, leathery, chalky one. Often they are invaded by fungi, such as species of *Fusarium*.

Internal freezing injury that becomes apparent only when the tuber is cut is shown by several types of discoloration. The ring type of discoloration is limited to the vascular ring and the tissues next to it; the net type is a blackening of the vascular ring and the fine strands that extend from it into the interior pith (fig. 34); and the blotchy type is irregular patches of color, ranging from opaque gray or blue to sooty black or reddish purple, which may occur in any part of the tuber. Individual tubers differ in susceptibility to internal freezing injury, and it is impossible to give a temperature at which this kind of injury begins. To prevent such injury, tubers should not be exposed to temperatures of 32° F. or below.

Usually it is not advisable to plant tubers showing freezing injury, although some of those only lightly affected may produce healthy plants.

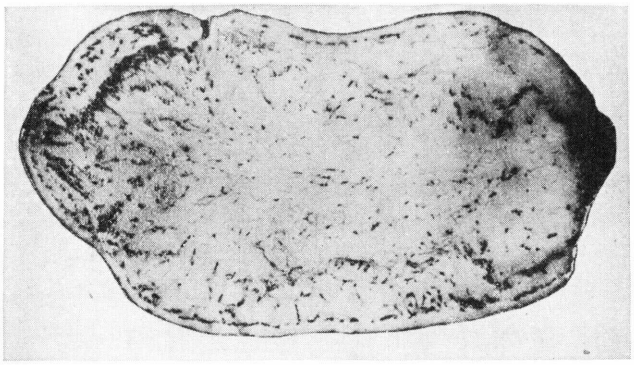

Figure 34.—Section of a potato tuber showing freezing injury.

INSECTS AND THEIR CONTROL

The common insect enemies of potatoes in the Western States are the Colorado potato beetle, flea beetles, the western spotted cucumber beetle, wireworms, the potato psyllid, aphids, the iris whitefly, leafhoppers, the seed-corn maggot, and the potato tuberworm.[2]

COLORADO POTATO BEETLE

The Colorado potato beetle is found in some parts of all the Western States except California and Nevada. The adults, or hard-shell beetles, overwinter in the ground at a depth of 4 to 12 inches and appear above ground early in May. The adult is half-round and 3/8 inch long. Its under side and legs are reddish brown. Its top is white or gray, with 10 narrow black stripes down the back and small dark spots near the head. Overwintered female beetles soon begin laying eggs in batches of 2 to 70, and continue until they have laid several hundred each. The yellow or orange eggs are usually found on the under sides of potato leaves. After 4 to 9 days they hatch, producing soft, brick-red slugs, or larvae. The slugs feed for 2 to 3 weeks, then drop to the ground and enter the soil. During the next 10 to 15 days the insects pass through the inactive, or pupal, stage and gradually change

[2] The full names of the insects mentioned in this section are as follows: Colorado potato beetle, *Leptinotarsa decemlineata;* green peach aphid, *Myzus persicae;* intermountain leafhopper, *Empoasca filamenta;* iris whitefly, *Aleyrodes spiraecoides;* lygus bugs, *Lygus hesperus, L. elisus,* and *L. oblineatus;* Pacific Coast wireworm, *Limonius canus;* potato psyllid, *Paratrioza cockerelli;* potato aphid, *Macrosiphum solanifolii;* potato leafhopper, *Empoasca fabae;* potato tuberworm, *Gnorimoschema operculella;* seed-corn maggot, *Hylemya cilicrura;* six-spotted leafhopper, *Macrosteles divisus;* sugar-beet wireworm, *Limonius californicus;* tuber flea beetle, *Epitrix tuberis;* western potato flea beetle, *Epitrix subcrinita;* western potato leafhopper, *Empoasca abrupta;* western spotted cucumber beetle, *Diabrotica undecimpunctata.*

to the adult form. The new adults appear above ground in the second half of June or in July. Another generation of adults may appear in August and September.

The Colorado potato beetle can be controlled with insecticides containing DDT or arsenicals. A single application made shortly after the eggs hatch usually is effective, but in some years one or more additional applications at 10- to 14-day intervals may be required. For dusting, use 5 percent of DDT or 25 percent of commercial calcium arsenate in talc or pyrophyllite. For spraying, use 2 pounds of 50-percent DDT wettable powder, or 4 pounds of commercial calcium arsenate, to each 100 gallons of water.

In mixing, applying, or otherwise handling a poisonous insecticide, special precautions should be taken against inhaling it in harmful quantities. A respirator protecting the entire face should be used when any large quantity is handled. After working with a poison, wash thoroughly any parts of the body that have been exposed to it.

FLEA BEETLES

The adults of a group of small insects having hind legs adapted for jumping are commonly known as flea beetles. Several kinds of flea beetles attack potatoes in the West. The most injurious are the tuber flea beetle and the western potato flea beetle. When abundant, the adult flea beetles seriously injure the foliage of potato plants and so cause reduction in yield. The larvae may feed in the developing tubers, thus impairing their quality. The larvae of the tuber flea beetle are particularly destructive.

The tuber flea beetle is a pest of potatoes in Colorado, western Nebraska, and the central and western parts of Washington and Oregon. The adult is black, oval, and approximately $\frac{1}{16}$ inch long. The beetles feed on both sides of leaves, often making so many small round holes that the leaves wither and die. The overwintered adults emerge from the soil in May and June. After feeding for a few days, the females reenter the soil beneath the potato plants and lay their eggs. In 5 to 8 days the eggs hatch, producing slender white larvae. The larvae feed on the small roots or in the tubers. The damage they do to tubers may be in the form of roughened trails on the surface or of tiny brown tunnels extending as far as $\frac{3}{4}$ inch into the tuber. The larvae feed for 2 to 3 weeks and then enter the soil, where within 10 to 14 days they transform into adult beetles. After emerging from the soil, the newly developed beetles feed for a few days and then reenter the soil and begin egg laying. In addition to one complete generation of adults, under favorable conditions partial second, third, and fourth generations are produced each season.

The western potato flea beetle occurs in Montana, Utah, Idaho, Washington, and Oregon. The adult is shiny black, greenish black, or bronze and approximately $\frac{1}{14}$ inch long. This beetle causes foliage injury similar to that caused by the tuber flea beetle. The adults overwinter above ground in clumps of grass or in other vegetation and become active in March, April, and May. The larvae feed chiefly on fine roots, but may also damage potato tubers. Usually their tunnels

are not so deep as those made by the tuber flea beetle larvae. The life cycle is slightly longer than that of the tuber flea beetle.

Flea beetles that attack potatoes can be controlled with insecticides containing DDT, cryolite, or arsenicals. Three to six applications may be required, and treatment should start as soon as three-fourths of the potato plants are through the ground. For dusting, use 5 percent of DDT, 30 to 35 percent of commercial cryolite, or 25 percent of calcium arsenate in talc, clay, or pyrophyllite. Where late blight occurs, a fixed copper fungicide may be substituted for a part of the talc or other diluent. Such fungicides vary in their metallic copper content. The mixture should contain 7 percent of metallic copper by weight.

In the irrigated parts of the West, a dust containing 5 percent of DDT, 0.5 percent of parathion, and 50 percent of dusting sulfur in talc, clay, or pyrophyllite is effective for control both of flea beetles and of aphids, which may be present at the same time. Sulfur may be hazardous to use in the humid coastal areas.

WESTERN SPOTTED CUCUMBER BEETLE

The western spotted cucumber beetle occurs in California, western Oregon, and western Washington. The adult is about ¼ inch long and ⅛ inch wide. It is light green, with 11 black spots on the back. In western Oregon the adults congregate in large numbers in plant debris during the fall and become active in March and April. In that area the adults may live until August and deposit 1,000 or more eggs each in moist soil beneath various plants. Eggs laid in March hatch in about 3 weeks. The larva is pale yellowish with a dark-brown head. The larvae feed on potato roots and also attack the tubers, forming tunnels that are somewhat larger and deeper than those made by flea beetle larvae. After several weeks of feeding the larvae enter the inactive, or pupal, stage in the soil. Adult beetles begin to emerge several weeks later. The first new beetles emerge in July and emergence continues into November.

The western spotted cucumber beetle can be controlled on potatoes by repeated applications of a 5-percent DDT dust. As egg laying begins early in the spring, the potato plants should be dusted as soon as one-half to two-thirds of the plants are through the ground. Dusting should be repeated at intervals as long as beetles are found on the plants.

WIREWORMS

Wireworms are the soil-inhabiting larvae of a group of insects popularly known as click beetles. Several species of these insects occur in the West. The Pacific Coast wireworm and the sugar-beet wireworm are particularly destructive to potatoes under irrigation.

The adults are slender, hard-shelled beetles, black or brown, ⅓ to ⅝ inch long. They emerge from the soil from March until June. After they have mated, the females reenter the ground and lay tiny white eggs. The eggs hatch in 3 to 4 weeks. The newly hatched larvae are white with dark jaws, and about 1/16 inch long. As the larvae grow, they become dark yellow. When full-grown they have a jointed appearance and a length of about ¾ inch. The insects pass through the

pupal stage in the soil. Under favorable conditions a few can become adults in 2 years, but most of them require 3 to 4 or even 5 years.

Wireworm larvae bore into potato seed pieces, rootstalks, and developing tubers, causing the tubers to be of inferior quality. One larva per square foot of soil will cause injury, and two or more will cause serious damage.

Soil fumigation with ethylene dibromide gives good immediate control of wireworms. The application should be made at the rate of 2 gallons of 85-percent ethylene dibromide, diluted with 8 gallons of kerosene or other mineral oil, per acre. The liquid must be placed at least 8 inches deep in the soil, in strips about 12 inches apart. It may be applied with a custom-built injection machine or with a home-made applicator attached either to a plow or to the back of a tractor. If a home-made applicator is used, the liquid fumigant should be allowed to run onto the plow sole next to the furrow that is being opened up, where it will be covered immediately by a furrow slice.[3] One to two weeks should pass before the potatoes are planted.

Single applications of DDT have remained toxic to wireworms for 5 or more years in eastern Washington and Oregon and in Ventura County, Calif. The DDT is applied as a spray or dust at rates of 10 to 20 pounds of DDT per acre and disked well into the soil to a depth of 6 to 8 inches. DDT kills wireworms slowly, and best results will be obtained by treating the soil several months before planting potatoes. Over a 5-year period the 10- or 20-pound dosage of DDT was not detrimental to plants, but excessive amounts applied as single or frequent applications might result in damage to some crops.

Solid stands of alfalfa create a dry, compact soil condition unfavorable for wireworm development. Consequently, an infestation of the Pacific Coast wireworm is greatly reduced by growing alfalfa for 3 or 4 consecutive years in a crop rotation.

POTATO PSYLLID

The potato psyllid is a destructive pest of potatoes in Colorado, Nebraska, Utah, Montana, and Wyoming. It occurs also in most other Western States except Oregon and Washington. While feeding, this tiny insect injects into plants a substance that causes the disease psyllid yellows, symptoms of which are curling and yellowing of leaves.

The adult psyllid is a narrow insect about $\frac{1}{10}$ inch long. The wings fold together rooflike above the abdomen. The newly emerged adults are light yellow to pale green, but they gradually change to brown, green, or black. A powdery white stripe extends across the middle of the body, and a white inverted-Y-shaped mark occurs at the tip of the abdomen. Adult psyllids often migrate long distances from south to north soon after emerging from hibernation. They appear in eastern Colorado during the first half of May and in Montana and Utah in June. The eggs are spindle-shaped and light yellow to orange, and are suspended from the leaves on short stalks. They hatch in 3 to 8

[3] For further information on equipment used to apply liquid fumigants to soil, see Control of Wireworms in Irrigated Lands With Ethylene Dibromide, U. S. Bur. Ent. and Plant Quar. EC–6, 1948. [Processed.]

days. The young psyllids, or nymphs, are flat, scalelike, and light yellow or green. The nymphs require about 16 days to develop into adults. Three or more generations occur each season, the number increasing from north to south.

The potato psyllid can be controlled with insecticide dusts containing 3 to 5 percent of DDT. In years of severe psyllid outbreaks, potato plants should be dusted every 10 days.[4]

APHIDS

Several species of aphids, or soft-bodied plant lice, attack potato foliage in the West. The green peach aphid and the potato aphid cause the most damage. When full-grown, these aphids are about 1/16 inch long, oval, and green. They greatly reduce the yield of tubers by sucking the juices from the foliage and cause still greater losses by carrying viruses from diseased to healthy plants.

Winged aphids are produced on overwintered host plants in April and May. They fly to potato fields, where they feed and move from plant to plant depositing living young on the under sides of leaves. After 1 to 2 weeks the young aphids become mature, wingless females, which likewise deposit living young. After several generations, or from about June 15 to July 15 in central Washington, winged aphids are again produced on potatoes. These fly to other potato fields, or to various other crops and weeds, and begin another series of generations of wingless aphids. Winged aphids are produced again in the fall. Aphids pass the winter chiefly in the egg stage and on woody plants.

A 5-percent DDT dust applied to potato plants every 10 to 14 days will prevent the increase of aphids to numbers sufficient to cause direct damage by their feeding. In irrigated areas of the Northwest, where the aphid-borne disease leaf roll is a serious problem, it is suggested that five applications of a dust containing 5 percent of DDT plus 0.5 percent of parathion plus 50 percent of dusting sulfur with talc, clay, or pyrophyllite be made with ground equipment. Placing vine-spreader attachments in front of the tractor wheels of the duster makes it possible to use ground equipment throughout the growing season without damaging the potato plants.

IRIS WHITEFLY

The iris whitefly is an abundant pest of potatoes in central Oregon and central Washington. The adult is white, triangular, and slightly less than 1/16 inch long. The adults overwinter in plant debris and become active in March and April. They deposit small gray eggs on the under sides of leaves. Enormous numbers of eggs may be deposited on late-crop potatoes in August and September. The larvae and pupae are fragile, flat, scalelike creatures, leaf green in color. There are several generations each year.

A 5-percent DDT dust applied every 10 to 14 days will control the adult whiteflies. Dusts containing 3 or 4 percent of nicotine are effective against the larvae.

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[4] Control of the potato psyllid is discussed on page 34 of this bulletin.

LEAFHOPPERS

Leafhoppers suck the juices from potato plants, and when present in large numbers may reduce the yield of tubers. Some species carry virus diseases to healthy plants and others are the direct cause of diseased conditions in the leaves fed upon. The intermountain leafhopper occurs in Utah, Idaho, and eastern Washington and Oregon. In feeding the leafhoppers remove the green coloring matter from the leaves, causing them to turn white or yellowish. East of the Continental Divide the potato leafhopper causes a diseased condition known as hopperburn. The leaf turns yellow around the margin and at the tip, then curls upward and rolls inward. The affected part of the leaf becomes brown, dry, and brittle. In New Mexico the western potato leafhopper causes hopperburn. The six-spotted leafhopper, which occurs in most of the Western States, transmits the purple-top wilt, or aster yellows, virus to potatoes.

Leafhoppers affecting potatoes are small wedge-shaped insects, approximately ⅛ inch long. The adults are usually pale green or yellow and may be marked with small white spots on the back or black spots on the head. The adults emerge from plant debris in the spring and insert their eggs into living plants. The young leafhoppers, or nymphs, are agile pale-green creatures, found chiefly on the under sides of leaves. There are two or three generations each year.

Dusts containing 5 percent of DDT are effective against leafhoppers on potatoes. Usually two or three applications are sufficient, but a larger number may be required where leafhoppers that cause hopperburn or carry viruses affecting potatoes are present.

SEED-CORN MAGGOT

The seed-corn maggot is the larva, or maggot, of a fly. This fly is smaller than a house fly and holds its wings closer to its body. The adults appear very early in the spring. They lay eggs on the soil and on decaying vegetable matter. The small white maggots that emerge from the eggs feed upon both living and dead plants. They seem to prefer the sprouting seeds, seedlings, or decaying parts of such plants as beans, corn, peas, and potatoes. Seed pieces on which the maggots feed often decay, with the result that they cannot produce healthy plants. The feeding always begins on a cut surface of the seed piece or where the skin has been broken. Damage may be severe during a cool, wet spring. The seed-corn maggot also carries blackleg infection from diseased to healthy plants.

The best known way of controlling the seed-corn maggot as a potato pest is to allow the potato seed pieces to heal, or suberize, before they are planted.[5] The conditions permitting seed pieces to suberize satisfactorily are described on page 9 of this bulletin.

LYGUS BUGS

Several kinds of Lygus bugs develop on certain legumes such as alfalfa, and when crops of the legumes are cut large numbers of the insects are likely to fly to nearby potato fields. The bugs feed on the

[5] Further information on control of the seed-corn maggot as a potato pest is given in U. S. Dept. Agr. Tech. Bul. 719, Prevention of Damage by the Seed-Corn Maggot to Potato Seed Pieces.

tender new leaves and small stems of potato plants, causing them to wilt and die.

The adults are flat, 3/16 inch long, and pale green to dark brown often tinged with red, yellow, or black. They overwinter in vegetation, and appear in March and April in Washington and Oregon. Eggs are deposited in the stems of growing plants and hatch in about 10 days. The nymphs resemble the adults in shape and are yellowish or bluish green. Nymphs may appear in small numbers in central Washington in May, but they are most abundant in June. There are three to five generations each year.

Insecticide dusts containing 5 percent of DDT are effective against adult lygus bugs on potatoes. Two or three applications may be required during the season in potato fields near fields of alfalfa. Particular attention should be given to the potatoes after each cutting of alfalfa.

POTATO TUBERWORM

The potato tuberworm attacks potatoes and related crops. The adults are small gray moths, which deposit pearly-white eggs on the leaves and stems of plants. The eggs hatch in a few days, and the larvae mine the stems and leaves. The mature larva is about 2/5 inch long and white, with a pinkish cast on the back. When infested potato foliage dries, the worms enter cracks in the soil and attack the tubers. They tunnel throughout the tubers, making them unmarketable. The moths may lay eggs on tubers that after being dug are left uncovered in the field overnight. Egg laying and development of the insect may continue during the winter under most storage conditions. This pest is established in California, and has been found in limited numbers during some years in Arizona, Colorado, Idaho, Nebraska, and Washington.

The tuberworm is best controlled by good cultural practices, careful clean-up measures, and fumigation of storages. In infested potato fields, the tubers should be kept well covered with soil until harvest, which should be as soon as possible after they reach maturity and before the vines die. The tubers should be removed from the field the day they are dug. All infested tubers, culls, and volunteer potato plants should be destroyed. Uninfested potatoes should not be stored in or near a storage place that has contained potatoes unless the place has been cleaned and fumigated with methyl bromide. Tuberworms within potatoes held in dry storage or in refrigerator cars may be killed by fumigating for a 2-hour period with methyl bromide at the rate of 2 pounds per 1,000 cubic feet of space including that occupied by the tubers. During the fumigation process the storage house or refrigerator car should be kept tightly closed, the mixture of air and fumigant should be circulated, and the air temperature within the storage house or car should be kept above 70° F.

Methyl bromide is a poisonous, odorless gas, which should be handled with extreme caution. Anyone working with it should wear a gas mask. The work should be supervised by a commercial fumigator or some other person thoroughly familiar with fumigation practices.

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